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THE
RAILWAYS
OF
GREAT BRITAIN AND IRELAND.

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THE
RAILWAYS
OF
GREAT BRITAIN AND IRELAND

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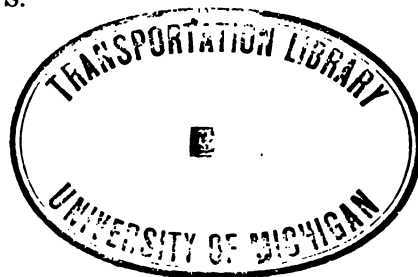
BY
FRANCIS WHISHAW, CIVIL ENGINEER,
MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS.

" Utilis agris,
Utilis et bellorum et pacis rebus agendis."
JUVENAL, Satir. xiv.

SECOND EDITION,
WITH SOME ADDITIONAL USEFUL PLATES.

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To
The Railway Capitalists
OF THE
UNITED KINGDOM.

This Volume is respectfully
Dedicated
By their obedient Servant
Francis Shishaw.

INTRODUCTION.

As it is highly gratifying to the wearied traveller, when reaching the end of a long and perilous journey, to recount the numerous obstacles which have for a while impeded his course, and to tell of his adventurous expedition when sitting around the cheery winter hearth; so, when the difficulties of a tedious and laborious undertaking have at length been overcome by long-continued exertions and unceasing watchfulness, amid the trials which have arisen, and the numerous impediments which have from time to time been cast in the way of its accomplishment, the recollection of by-gone days thus spent is peculiarly cheering, and the mind is filled with hope for the future success of the favourite work which has cost so much time and patience in bringing to an end. Such are naturally our feelings with respect to the present volume, which we have desired to make as extensively useful as possible to every class of persons interested in railway-communication.

It is the peculiar privilege of the present generation to live in the times of railways, the introduction of which, rationally considered, must surely be esteemed one of the greatest blessings ever conferred on the human race. The prince, the peer, and the peasant, are alike benefited by the substitution of the "way of iron" for the old turnpike-road; yet who that is of sufficient age, and has made the journey, does not remember enjoying the comparatively smooth

travelling on the beautiful mail-road to Holyhead ; that great work of the justly celebrated TELFORD, at once the pride of Englishmen and the admiration of foreigners.

Yet, so it is ; we go on improving : canals and turnpike-roads have, as it were, had their day, and now must yield the palm to that greatest achievement of modern times, the iron railway. We humbly venture an opinion, that the general introduction of railways, in conjunction with that of the mighty steamers which ride swiftly and majestically over the troubled ocean, is the preparatory means whereby the civilisation of the whole world will eventually be accomplished. Time, to those blessed with the advantages of railways, is, as it were, of thrice its former value ; while money, considered relatively, is already increased in a two-fold ratio : and the day is not far distant when the means of railway travelling—looking to the increasing facilities and improvements which are constantly taking place—will be yet much more within the reach of the humblest classes of the people.

If at this time an apparently complete and well-appointed railway require a given sum per mile from each class of passengers, fairly to reimburse the enterprising capitalist for his outlay ; and if hereafter an equally efficient system of railways shall be introduced, by which at least one-half of the present cost will suffice for its construction, it follows, *cæteris paribus*, that the passenger-fares may also be reduced to a very considerable extent. As an apt illustration, we may suppose the first-class passenger-traffic on a given railway to be equal to half of that of the second-class traffic, and that the third-class traffic is also in the same ratio with respect to the second ; we may further suppose the first-class fare to be at the rate of $3d.$, the second-class fare at the rate of $2d.$, and the third-class fare at the rate of $1\frac{1}{2}d.$ per mile respectively. By adding the amount of two second-class fares, and one first and one third-class fare together, we have $8\frac{1}{2}d.$; from which, if the government-duty of one-eighth of a

penny per mile be deducted, there will remain 8*d.* for the railway company for the carriage of four passengers over one mile of their line. But another company has constructed a railway for half the cost of the first, and has an equal share of traffic; but having expended only half the amount of the first company, is enabled to carry passengers at a very much reduced rate per mile; not, however, equal to half, on account of the government-tax, which remains the same as in the first case: for if the second company were to charge only half the already quoted fares, they would sustain a loss of 6½ per cent, supposing the desired rate of interest on the capital expended to be the same in both cases. For instance, if the fares in the second case be taken at 1½*d.*, 1*d.*, and ½*d.* respectively, the collective amount of two second-class fares, and one first and one third-class fare as before, would be 4½*d.*; from which, deducting the government-duty, there would remain only 3½*d.* for the company, or ½*d.* less than half the receipts per mile by the higher scale of charges. But if, on the contrary, a fixed duty, say at the rate of 6½ per cent, on the gross amount received by the company for the carriage of passengers, were substituted for the unequally pressing poll-tax, the fares might then be reduced in proportion to the diminution in cost of the original construction of the railway.

It appears, therefore, that in regarding all the different cases which at present exist, or may hereafter arise, an *ad valorem* duty would be by far the most equitable to all parties; and further, that it is of the first importance, not only to the public at large, but also to future railway proprietaries, to endeavour, by all means in their power, to reduce the first cost of railways to the minimum consistent with the stability of the works, and an amount of accommodation equal to that afforded by the present costly undertakings, but, above all, the safety of the passengers.

The particular attention of our readers is directed to the Reciprocating System of Railways, which is fully explained and illustrated

in this volume. Constructed in the most substantial way, furnished and appointed in the most complete manner, and affording all the accommodation of the best railways of the present day, the original construction and entire furnishing would be reduced to an average throughout the United Kingdom of something like 15,000*l.* per mile ; for we have taken, it will be seen, a very large amount of mixed traffic as the basis of our calculations. By this system *accidents by collision*, which of late have unfortunately been but of too frequent occurrence, are rendered next to impossible, as will appear evident to any one who will carefully read the account of the proposed mode of carrying on the traffic.

We have given in detail the cost of the construction and working by this system, that all may weigh the matter for themselves. We fancy we hear the voice of some interested individual crying out vehemently against the introduction of this plan ; for within himself he knows full well it will at once call to mind the millions of money that have been expended on the great railways by which England is already intersected—millions, that would have furnished Ireland with not fewer than 500 miles of well-appointed railways. We will, however, say no more on the subject at present ; but only request a careful perusal by each of our readers of the account of the Reciprocating System.

The general contents of the present volume, which are founded on facts obtained on our railway trip, extending over something like 7,000 miles ; or furnished through the kindness of the individuals whose names are recorded in a subsequent page, will be seen by the Table of Contents. Where the information in any part appears scanty, or where there is altogether a lack of those details which are naturally expected, it is not for want of application in the proper quarters, or saving of trouble, labour, or expense to ourselves ; for we have visited, with very few exceptions, every passenger-railway in the United Kingdom.

If we give an outline of the contents of the account of the London and Birmingham Railway,—and here once more let us reiterate the unexampled assistance we have received during our labours from Richard Creed, Esq., the very able and intelligent secretary of that large establishment,—it will give some notion of the extent of information we wished to have afforded as to each railway at present open to the public. First, then, in order is the Introduction; 2d, the Acts of Parliament, &c.; 3d, the different openings of the line; 4th, the general course of the railway, and shortest radius of curvature; 5th, the gradients; 6th, the gauge of way, &c.; 7th, the description of permanent way, drainage, and fencing; 8th, the earthworks; 9th, the viaducts and bridges; 10th, the tunnels; 11th, the stations and depôts, including the coking-department; 12th, the description of coke purchased, &c.; 13th, the passenger-carriage department; 14th, the wagons-department; 15th, the trains; 16th, the fares, passenger-traffic, &c.; 17th, the locomotive engines; 18th, the establishment; 19th, the cost of the undertaking; 20th, the original estimate; 21st, the annual expenditure; and, lastly, the annual revenue. Besides each description, amounting to fifty-eight in number, a detailed account is given of practical experiments; shewing the ordinary working of the principal railways in the kingdom, the results of which bring to light some important facts with regard to laying out railways. We can here do no more than refer our readers to page 246, to the tabulated results in the Appendix, and to the illustrative diagrams in Plate 15.

The Tables in the Appendix, shewing the proportions of 630 locomotive engines used on British and foreign railways, have been constructed at the expense of much time and labour, and necessarily occasion a considerable additional outlay. But this part of our volume could not have been produced without the kind aid of the principal manufacturers of locomotive engines, whose names are included in the catalogue in a subsequent page. We have on

several occasions referred to the *Railway Times* for information as to traffic, &c. in cases where we had not the printed reports, as circulated among the respective proprietaries; the statements given in that excellent weekly journal we have generally found to be exceedingly accurate.

We may here introduce the name of Mr. Frederic Rumble, the accurate draftsman, by whom most of the drawings were made under our directions; and of Mr. Beever, the engraver, who has not only executed several of the plates in his usual excellent style, but, above all, has been punctual to his time, which is, indeed, a very great recommendation.

A detailed Table of Contents is introduced, for the sake of easy reference to the account of any particular railway, or subject connected therewith.

The Plates are explained in a Table of Reference.

Lastly, we have added, in the Appendix, the Standing Orders of both Houses of Parliament as relating to Railway Bills only; as also Lord Seymour's Act for the use of all persons in any way connected with the daily working of British railways.

It is now our pleasing duty to acknowledge the great assistance we have derived from all the principal railway-companies of the United Kingdom; and of the uniform attention and kindness we have received from the very many disinterested individuals with whom it has been our good fortune to come in contact during our arduous undertaking.

Our path has on several occasions been impeded by those who would gladly have marred our project, oftentimes presenting a very discouraging appearance; nothing daunted, however, by the sinister motives of a few, very few, individuals throughout the whole extent of the British isles, we have gone on our way rejoicing, in the hope that the results of our almost incessant labours for sixteen consecutive

months might prove extensively useful to the large and increasing portion of the British people, whose interests are so entirely interwoven with the railways of the United Kingdom.

We shall here record the names of the railway companies and individuals already alluded to :

The London and Birmingham Railway Company.
The Great Western Railway Company.
The Grand Junction Railway Company.
The Newcastle and Carlisle Railway Company.
The Liverpool and Manchester Railway Company.
The Newcastle and North Shields Railway Company.
The York and North Midland Railway Company.
The Dublin and Kingstown Railway Company.
The Ulster Railway Company.
The Leeds and Selby Railway Company.
The Stockton and Darlington Railway Company.
The South Eastern Railway Company.
The Arbroath and Forfar Railway Company.
The Sheffield and Rotherham Railway Company.
The North Union Railway Company.
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The Birmingham and Gloucester Railway Company.
The Northern and Eastern Railway Company.
The London and Blackwall Railway Company.
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APPENDIX.

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EXPLANATION OF THE PLATES.

THE Plates are seventeen in number, and consist of Elevations of Locomotive Engines belonging to the different Classes; Longitudinal and Transverse Sections and Details of an Engine belonging to class A; Elevations, Plans, and Sections, of Railway Carriages and Wagons; Sections of Rails; Details of different kinds of Permanent Way, Fencing, Drainage, and Signals, &c.; Blackwall Railway Carriage Apparatus, and Diagram to illustrate the mode of working that line; Diagrams to illustrate the Duty done by Locomotive Engines on Planes of different Inclinations; Diagram to illustrate the mode of working a Railway by the Reciprocating System, and Plans of a Terminal and Intermediate Station arranged for this particular system; with a Railway Map of the United Kingdom.

PLATE I.

Elevation of an engine belonging to class A, similar to those used on the Great Western Railway (see Table VIII. of Locomotive Engines, in the Appendix). For classification of engines, see p. 446.

NOTE. — The scale is uniform to all the elevations of the locomotive engines throughout, viz. 3 feet to one inch.

PLATE II.

The figures on this Plate are to illustrate the mode of working a railway by Whishaw's Reciprocating System, and consist of a diagram shewing the situation of the terminal and intermediate stations with respect to each other; a plan of a terminal station and dépôt suited for carrying on a very extensive and mixed traffic; a plan of a principal intermediate exchange-station; and transverse sections of a cutting, embankment, bridge, and tunnel.

PLATE III.

The sections of no fewer than eighty-four wrought-iron rails belonging to British and foreign lines are shewn in this Plate; and most of them are particularly referred to in the body of the work.

PLATE IV.

Elevations of four different kinds of engines, viz. Victoria, belonging to class C, at work on the Arbroath and Forfar Railway (see page 5).

A small goods-engine, *Orion*, belonging to class D D 1, calculated for a nearly level line: 18-inch cylinders, 16-inch stroke; wheels, 4 feet 2 inches in diameter; gross weight, 9 tons 6 cwt.; net weight, 8 tons 1 cwt.

A passenger-engine, *Phœnix*, built by Messrs. Edington and Son, of Glasgow, and belonging to class E. (The design of the chimney is altered to a more modern shape than that of the Phœnix.)

A large goods-engine, *Albert*, belonging to class E E: cylinders, 15 inches; stroke, 18 inches; four coupled wheels, of 4 feet 7 inches diameter gross weight, 12 tons; net weight, 10½ tons.

PLATE V.

Elevation of an engine (class E) and tender, constructed by Messrs. Robt. and Wm. Hawthorn, of Newcastle-upon-Tyne, who have acquired great celebrity by the improvements they have effected in locomotive engines. For the proportions of this engine, see Table XIII. of Foreign Locomotives, in the Appendix, No. 245 (maker's number). The tender is furnished with a compound lever-brake, by which each wheel is doubly locked—a most important improvement for the effective working of railways having third-class gradients.

In Messrs. Hawthorn's modern engines, the greatest improvement is the mode adopted of working the slide-valves by a simple combination of levers, whereby eccentrics are entirely dispensed with, and the lead of the slide regulated with the greatest precision, so as to produce, when required, the maximum effect of the propelling power of steam.

PLATE VI.

Elevations of four engines, viz. the London and Birmingham passenger-engine (class E 1); and merchandise-engine (class E E 1)—see Table XI. of British Locomotive Engines, in the Appendix; the American engine *England*, built at Philadelphia, and working on the Birmingham and Gloucester Railway (see page 29), belonging to class F; the *Novelty* engine, belonging to class B, furnished with Stephenson's gearing, and calculated for railways which are nearly level: 12-inch cylinders, 18-inch stroke, driving-wheels 5 feet in diameter, bearing-wheels 3½ feet in diameter; the net weight being 13½ tons.

PLATES VII., VIII., and IX.

Longitudinal and transverse sections, and details of the working-parts of a locomotive engine belonging to class A. In Plates 7 and 8, the same letters of reference answer for those parts which are shewn in both sections.

E is the fire-box divided cross-wise by a water-channel towards the bottom, in order to obtain a larger amount of heating surface than usual.

X X, the grate-bars.

I, the fire-box door.

a a a, tubes extending through the boiler to the smoke-box, at the other end of the engine, by which communicative heat is imparted to the water (in the boiler) by which they are surrounded.

H, the steam-dome, which, with the funnel-pipe G, tends to prevent the steam being admitted to the cylinders in an impure state, or what is usually called *priming*. This takes place to a considerable extent in engines where the entrance to the steam-pipe is but little elevated above the surface of the water, as the steam, in such case, enters the cylinders charged with a considerable proportion of water.

F, the regulator by which the steam is admitted into the steam-pipe *f*, leading to the steam-chamber above the cylinder A.

j m, the front and hind steam-ports by which the steam is admitted first in front, and then behind the piston *n*.

k, the waste-port.

T, the slide-valve, which is moved by the gearing shewn in Plate IX. Fig. 2; leaving the cylinders, the steam escapes by the blast-pipe M into the chimney R.

The blast-pipe is considered one of the greatest improvements that have been effected in the

locomotive engine; for by it a continual blast is produced through the fire by the air rushing up from under the grate-bars, and by the boiler-tubes into the chimney-box to supply the vacuum formed by the condensation of the steam as it issues from the top of the blast-pipe at every stroke of the piston. The blast-pipe rests on and is bolted to a breeches-pipe (see Plate 8), which communicates with the steam-chambers *ss*. By means of the piston-rod *o* (which passes through a stuffing-box in front of the cylinder), the coupling *r*, and the crank *u*, motion is given to the cranked axle of the driving-wheels.

t t, axles of the four bearing wheels.

O, the feed-pipe from tank of tender to the boiler.

K, the man-hole by which the boiler is examined.

b, the safety-valve; and *Q*, the spring-balance for shewing the amount of pressure of the steam within reach of the engine-driver.

L, the safety-valve without reach of the engine-driver.

c, the steam-whistle, which is shewn on a larger scale in Fig. 6, Plate IX.

i, cock for emission of steam from the cylinder when required.

P, cock for the emission of water from the cylinder.

W, the plough for removing impediments from the surface of the rails.

N, buffer of the carriage-frame.

q, the coupling-chain.

The general proportions of this engine are as follows:—

14-inch cylinders; 18-inch stroke. Boiler, 45 inches in diameter. Ninety-one tubes of 2 inches external diameter, and 8 feet in length. Fire-box, 39 inches long, 42 inches high above grate-bars towards the tubes, and 46 inches high towards the fire-door; width, 42 inches. Average height of water-channel, 19 inches; width, 4½ inches, and length, 42 inches. Height of chimney above smoke-box, 6 feet 3 inches; diameter, 15 inches; steam-passage induction-pipe 3 inches in diameter, eduction-pipe 4½ inches in diameter; blast-pipe, 3 inches in diameter; driving-wheels, 5 feet 6 inches in diameter; bearing wheels of 3 feet 8 inches diameter.

PLATE IX.

Details of the working parts of a locomotive engine.

Figs. 1, 3, and 4, details of the driving-wheel.

Fig. 2, the gearing for working the slide-valves.

Fig. 5, glass gauge for ascertaining the height of water in the boiler.

Fig. 6, section of the steam-whistle.

Fig. 7, fire-box door.

Figs. 8 and 9, couplings.

Fig. 10, angle-stay to secure the boiler to the carriage-frame.

Fig. 11, the hand-pump.

Fig. 12, sections of a six-wheel tender, shewing the tank, coke-floor, feed-pipe, &c.

Fig. 13, the Stanhope lever-brake attached to the tender, for locking the three wheels on one side at the same time.

Fig. 14, cock to let off water from the cylinder.

Fig. 15, the regulator.

PLATE X.

Elevations of the Great Western carriages (see description, page 153).

PLATE XI.

Plans of Great Western carriages.

PLATE XII.

Elevations and Plan of Grand Junction Railway carriages (see description, page 131).

PLATE XIII.

Plans, elevations, and sections of Birmingham and Gloucester Railway carriages (see description, page 27).

PLATE XIV.

Birmingham and Gloucester Railway wagons, in plan and elevation.

PLATE XV.

Diagrams to shew the duty performed by the engines on the Liverpool and Manchester, London and Birmingham, Grand Junction, and Great Western Railways—referred to in the account of Practical Experiments.

PLATE XVI.

Details of permanent way, comparison of gauges, crossings, fixed points, slide-rails, fencing, gates, level crossing and gates, drainage, signals, water-column, wooden turn-table, mile-standards and gradient-standards.

Diagram to illustrate the mode of working the Blackwall Railway (see description, page 265), and the disconnecting carriage-apparatus belonging to the same railway, fig. 45, in which *a* is the lever with the grip or tongue *c*, and *b* is the rope; when the carriage is to be let off, the lever is moved into the position shewn by the dotted lines, and the rope at once falls on to the sheeves.

Fig. 47 shews the coupling for the carriages of the same railway.

PLATE XVII.

Map of the United Kingdom, shewing distinctly the different lines of way completed or in progress, and those intended; and also the steam-boat tracks from various English ports to those of Ireland and France.

DESCRIPTION OF RAILWAYS.

DESCRIPTION OF RAILWAYS.

ARBROATH AND FORFAR RAILWAY.

AMONG the railways of Scotland already opened to the public, not one seems to have produced such extraordinary results as the short line between Arbroath and Forfar. It is a fact worth recording, that the passenger-traffic between these two places, antecedent to the opening of this railway, was so insignificant in amount as not to be sufficient for the support of a single public conveyance. The case is now very different; not fewer than four trains pass daily in each direction between the terminal stations. This statement, however, would not of itself be sufficient to shew the self-creativity of railway-traffic, as exhibited so strikingly in this line, without also adding the number of passengers conveyed in a given time. Nearly 500 passengers, on an average, travelled daily on this line for ten weeks ending the 10th of August, 1839, which is at the rate of about 150,000 per annum, exclusive of Sundays, on which days it is well known that public conveyances of every description, save only the mails, are strictly prohibited from travelling throughout Scotland. In the ten weeks above alluded to, not less than 127 tons of merchandise were, on an average, conveyed on this line daily, being at the rate of nearly 40,000 tons per annum; and this at a period when the railway had been opened but a very short time.

To the exertions of Mr. Lindsay Carnegie, the highly respectable and indefatigable chairman, may be attributed, in a great measure, the formation of this railway, which has already opened out many important branches of commerce, and which contributes so largely not only to the comfort and convenience of the higher, but also of the humbler classes of this district, who

are enabled, by the very low charges, to avail themselves of this economical mode of conveyance.

We were much surprised, when examining this line in September last, to see a party of reapers travelling by the third-class railway-carriages in preference to walking to their work; and we found on inquiry that this was by no means an isolated case, but of every-day occurrence. In fact, with the low fares adopted on this line, it is more economical for the poor man to ride than to walk. It is much to be desired that the Government tax of one-eighth of a penny per passenger per mile, which is now so unfairly levied on this and other railways, particularly in Scotland, should form an *ad valorem* on the amount received for passengers, instead of a fixed charge per passenger. The present method of levying this tax operates very unfairly on the shareholders of those railways, distinguished for their more than ordinary amount of public accommodation; and if not altered must certainly check the progress of railways throughout the rural districts of Great Britain. It is notorious, particularly in Scotland, that wherever railway-fares have been lowered, the traffic has been invariably increased to an amazing extent; and but for the unequal levying of this tax, the proprietors of these great national undertakings would be very fairly remunerated, which can scarcely ever be the case while it remains unaltered. For the first-class passengers, the average fare per mile on this line is 1·961*d.*; for the second-class, 1·461*d.*; and for the third-class, ·98*d.*

GENERAL DIRECTION.—This railway, whose eastern terminus is close to the harbour of Arbroath, passes from thence, in a direction nearly north, towards St. Vigean's Kirk, where it slightly curves, and takes a course about north by west to the south of Friockham; thence curving to the west, passes south of Guthrie Castle, and pursues nearly a direct course to the south of the village of Lunnan Head. Here it again curves, and by a direct line nearly three quarters of a mile in length, and in a direction south by west, reaches the Forfar station; the whole length being rather more than fifteen miles. The curvature of the main line is unobjectionable; the greatest curve, which is near St. Vigean's Kirk, being of about three quarters of a mile radius.

The whole is an ascending line from Arbroath to Forfar, rising altogether about 221 feet. Mr. Grainger, the engineer, in graduating this line, has

judiciously interspersed short level planes, which materially assist the locomotive engine in ascending the inclines, and check its velocity while descending. The inclinations vary from 1 in 130 to 1 in 1155; and there are five level planes: it is therefore as favourable, in a mechanical point of view, as the nature of the country would allow.

PERMANENT WAY.—Mr. Grainger has adopted on this line, as well as on the Dundee and Arbroath Railway, which joins it near the Arbroath harbour, a gauge of 5 feet 6 inches. He states as his reason, that he considers the English gauge too narrow, and the Great Western gauge too wide; he has, therefore, taken something like a mean, which would enable him to allow sufficient space for the proper construction of the locomotive engines, and also afford more useful space in the carriages.

Although the bridges and earthworks are all formed for a double line, as yet only a single way is laid. The gauge, as has already been stated, is 5 feet 6 inches, the intermediate space 6 feet 5 inches, and the side spaces each 5 feet 6 inches; the top width of embankment is, therefore, 28 feet 5 inches. The rails are of the single parallel form (see Plate III. fig. 1), and weigh 48 lbs. to the yard. They are fixed in chairs of ordinary form, with 3 feet bearings; the intermediate chairs weighing 14 lbs., and the joint chairs 20 lbs. each. The rails are secured to the chairs by wooden keys. Both cross sleepers and stone blocks are used as footings for the rails; about three fourths of the whole way being laid with hard sandstone blocks. The cross sleepers are 8 feet 6 inches long, and have a scantling of 8 inches by 4 inches. The ballasting is of broken stone 21 inches in thickness, and laid to nearly the whole width of embankment, or cutting.

The fencing consists partly of posts and two rails, but chiefly of stone walling, laid dry to a proper form with double batter, and coped in mortar. The bridges are constructed chiefly of stone, but some of cast-iron; those over the railway are 28 feet in span. There are about twenty-one bridges over and under the railway; one level turnpike-road crossing and eleven level high-road crossings: the gates are made to shut both across the railway and roads intersected. In the fifteen miles there are about nine sidings. The castellated bridge over the entrance to the grounds of Guthrie Castle appeared to me the most striking feature along the line in an architectural

point of view. The distance-standards are placed at intervals of half a mile each on one side of the way only; and the miles are measured from the Arbroath terminus.

The earth-works, generally, are not heavy. The greatest depth of cutting is 36 feet; and the greatest height of embankment 29 feet. In passing over Rostennet Moss, near Forfar, a considerable quantity of materiel was absorbed in forming the embankments to the proper heights. The works were let to twelve contractors, and occupied about two years in executing.

The passenger-station and dépôt, which are together placed at Arbroath, are conveniently situate in Catharine Street. The buildings are sufficiently architectural to present a pleasing appearance. The internal arrangements consist of a ticket-office, a general waiting-room, and adjoining a room for ladies: the ladies, however, ought to have a separate entrance. There is also the manager's room; the passenger-shed is 80 feet in length by 27 feet wide, with a single way only; the side-platform is 7 feet wide. The carriage-house and engine-house are placed contiguous and parallel to the passenger-shed; the carriage-house having only a single way running through it into the repairing-yard, and the engine-house two lines of way. In the rear of the latter the workshops are situated; the water-station is removed but a short distance from the engine-house; a weigh-bridge for the *up* and another for the *down* traffic, are conveniently placed at this dépôt. The weighing-machine is from the works of Messrs. Carmichael at Dundee, and is found to answer its purpose exceedingly well.

Besides the terminal, there are six intermediate stations. At the time we visited this work, no great expense had been incurred in the erection of intermediate station-houses; but as the funds of the Company increase, no doubt neat and convenient buildings will be erected for this purpose, as also a second line of way laid down, which is the more especially required on account of the mixed traffic of this railway.

The turn-tables are of iron, 12 feet in diameter, and were furnished from Shott's ironworks, Edinburgh.

The width of land averages above 22·33 yards from end to end; and the whole area includes about 120 acres. Twelve yards is the least width.

CARRIAGE-DEPARTMENT. — The carriages used on this line are of three descriptions — mixed, second class, and third class; and were built by Mr. Thompson of Stirling.

The mixed carriages, which are designated by names, as on the Grand Junction Railway, have each three compartments; the middle being for first-class, and the end compartments for second-class passengers; the latter are furnished with curtains in place of glass or shutters: these carriages are of full size for thirty persons.

The second and third-class carriages are calculated to hold at least thirty-six passengers. The third-class carriages are without roofs, but have seats; and to each a luggage-compartment is attached. The Company's stock of carriages at present consists of four mixed, two second, and three third-class carriages: the wheels are 3 feet in diameter, and of malleable iron. The wagons and trucks, about 120 in number, are of various sizes and weights, with wheels $2\frac{1}{2}$ feet and 3 feet diameter: some of the wagons have a capacity of 120 cubic feet, and weigh 30 cwt.

ANNUAL COST. — Under this head, the maintenance of way generally forms an important item. Hitherto this has been very moderate on the Arbroath and Forfar Railway — the number of men employed in this department not exceeding twenty daily; but then it is only the early part of the second year of working, and is therefore necessarily lower than it will be in future. The wages of the way-men are 12s. a-week each.

There are twelve men employed in the repairs of the engines, carriages, and wagons; besides two engine-drivers and two firemen.

LOCOMOTIVE DEPARTMENT. — The engines on this line, built by Stirling and Co. of Dundee, are three in number, and are called the Victoria, the Britannia, and the Caledonia: they have all outside cylinders and inside bearings; six wheels, viz. 5-feet driving-wheels, and carrying-wheels 3 feet 6 inches; 105 tubes, 2 inches external diameter, and 8 feet 5 inches long; fire-box, 4 feet long, 2 feet 6 inches wide, and 3 feet 6 inches high; boiler, 3 feet 9 inches diameter; diameter of chimney 12 inches, and height above smoke-box 6 feet; steam-passage equal to 10 square inches; and blast-pipe, $2\frac{1}{2}$ inches diameter. The Caledonia had travelled upwards of

16,000 miles, with a cost for repairs of about 7*l.*, including six new tubes. (See Table A of Results of Practical Experiments, in Appendix.)

There are three tenders, each weighing about six tons, and of sufficient capacity for 540 gallons of water and 18 cwt. of coke.

The coke is supplied by contract from the ovens at Arbroath belonging to Mr. Gow, and is made of Garesfield and Prudhoe Main Newcastle coal mixed in equal proportions, and supplied to the Company at 28*s.* 4*d.* per ton.

ACTS OF PARLIAMENT, &c. — The original capital of the Company was 70,000*l.*, in shares of 25*l.* each. The Act of incorporation received the royal assent on the 19th May, 1836, and empowered the Company to raise a capital in joint stock of 70,000*l.*, and an additional sum by loan of 35,000*l.* An amended Act was obtained in the session of 1840, which received the royal assent on the 3d of April, and authorised the Company to raise an additional sum of 55,000*l.*, making altogether 160,000*l.*

The line was opened throughout with a single way on the 3d January, 1839.

The receipts for traffic for the first fifteen months of the line being opened amounted to 9,522*l.* 18*s.* 3½*d.*, and 217*l.* 9*d.* for rents: together, 9,739*l.* 19*s.* ½*d.*; and the total expenditure for the same period to 6,672*l.* 7*d.*, being upwards of sixty-eight per cent on the revenue. The number of passengers who travelled on this line for the fifteen months, as above, amounted to 117,852; and the weight of merchandise, &c., for the same period, to 53,956 tons, being respectively at the rate of about 300 passengers and 138 tons per diem.

ARDROSSAN AND JOHNSTONE RAILWAY.

THE narrow gauge of 4 feet 6 inches has till recently been in general use in Scotland. Among the railways so constructed may be numbered that which runs from the harbour of Ardrossan through Saltcoats to Kilwinning. This railway, which has hitherto been entirely worked by horses, was con-

structed by the authority of an Act of Parliament obtained in the session of 1827. The whole of the main line has lately been remodelled, with improved gradients and heavier rails; the gauge of way being altered to correspond with the Ayrshire Railway, which in this respect is the same as most of the English lines.

COURSE OF RAILWAY. — Commencing on the west side of the harbour of Ardrossan, the line keeps parallel with that side for about ten chains; and thence, taking a very quick turn, follows a direction about east by south, crossing part of the harbour, and passing close to the Firth of Clyde, and between it and the corner of Princes Street, with a curve of 460 feet radius; thence passing by the old castle, and recurving with a radius of about 1600 feet, for a length of half a mile; thence continuing, with a curve of about three quarters of a mile radius, through Saltcoats; again nearing the sea within $3\frac{1}{2}$ chains, and taking a general direction of about east by north through Stevenston parish, passing near Dubbs and Todhills, just beyond which the Doura Branch diverges to the east; the main line continuing to the west of Cranberry Moss, and terminating by a junction with the Ayrshire Railway to the west of Kilwinning. The Doura Branch, leaving the main line, takes a course nearly east, passing under the Ayrshire Railway, at a distance of about 47 chains from the point of divergence, and half a mile beyond crossing the Garnock water, and curving with a radius of about 12 chains; thence taking a north-eastern direction for half a mile further, and recurving with a radius of about 15 chains, proceeds to its crossing of the Lugton water; beyond which the Fergus Hill Branch diverges to the left, the Doura Branch continuing by South Fergus Hill and Milburn; the course from the last divergence to opposite Milburn being in a direction east by south. From opposite Milburn, with a curve of about 12 chains radius, the line turns again into a north-eastern direction, and terminates at Doura coal-pit.

INCLINATIONS. — In the main line there were thirteen planes, commencing at Ardrossan harbour: the first being level; the next descending at the rate of 1 in 588; the third rising at 1 in 320; then succeeding the following inclinations, viz. 1 in 3181, 1 in 1100, 1 in 1564, 1 in 2260, the eighth plane

being level; the remaining five planes inclining at the rates respectively of 1 in 620, 1 in 700, 1 in 5862, 1 in 240, ascending; and lastly, 1 in 171, also ascending; the eastern being about 45 feet above the western terminus; and the whole length of main line being about 5 miles 42 chains.

By the alteration the planes are reduced in number to seven. The ratios of inclination are as follows, commencing at Ardrossan harbour:—First, level; second, 1 in 588; third, level; fourth, 1 in 400; fifth, level; sixth, 1 in 240; and seventh, 1 in 200: the two latter planes ascending; and the united lengths of level planes amounting to three miles. Thus, in point of inclinations the line is much improved.

The inclinations of the Doura Branch, which, at its commencement, inclines for rather more than a mile at the rate of 1 in 400, vary from 1 in 59 to 1 in 4866; the worst planes are 1 in 59, 1 in 73, and 1 in 78, ascending respectively towards Doura, which is about 77 feet higher than the point of divergence from the main line. The length of this branch is 3 miles 49 chains.

The Fergus Hill Branch, which terminates also at a coalpit, ascends from the Doura Branch at the rates respectively of 1 in 97, 1 in 67, 1 in 48, and 1 in 173: its whole length being about 43 chains.

EARTHWORKS, BRIDGES, &c.—The earthworks are light throughout. On our view of the main line, in Sept. 1839, we counted three bridges over the railway, six level road-crossings, and four level field or occupation-crossings, and five traverses. The original width of land was 28 feet, but by the alteration it is increased to 32 feet. The average cost of the land was about 100*l.* per acre. The gauge is increased from 4 feet 6 inches to 4 feet 8½ inches; and the intermediate space for the double way, which hitherto extended for a distance of 3 miles from the Ardrossan terminus, is 6 feet. The original rail is of fish-bellied form, and weighs only 28 lbs. to the lineal yard; but heavier rails have been laid down for the main line throughout (see Plate III. fig. 2): the bearings of rails are 3 feet, and the rails are set in chairs in the usual way. The old rails were supplied at 12*l.* a ton; the new 56 lbs. rails were contracted for at 11*l.* 10*s.* per ton, by Messrs. Kendrick and Co., of the Vorteg Ironworks, Newport, South Wales. The new chairs weigh from 18 to 19 lbs. each. The freestone blocks at present in use are of small

size, and cost 9*d.* each. The new blocks are 2 feet square and 9 inches thick; the price is 2*s.* each, or 8*d.* per cubic foot.

The fencing consists of posts and two rails, and of stone walls, 4 feet 6 inches high and 18 inches thick. The price of the latter is stated to be 6*s.* 6*d.* per superficial yard. The gates, which shut across the railway at level road-crossings, are of light bar-iron, hung between stone piers. This plan is much adopted in Scotland, and is by far the most economical mode in districts where coal, iron, and stone, are abundant. In cuttings, the side-drains are constructed of stone, and covered with flags.

TRAFFIC, CARRIAGES, &c.—The present traffic on this line consists chiefly of coals and passengers. The amount of coals from the Eglington coal-field is stated to be about 80,000 tons per annum; and the average number of passengers, for the three years ending September 1839, about 31,000 annually.

There are about 440 wagons in use on this line, which belong to the coal-proprietors. The weight of a wagon, including wheels, is 1 ton 14 cwt.; and the complement of coal in each 42 cwt. The gross load is, therefore, 3 tons 16 cwt.

The carriages hitherto used on this line were drawn by horses; each carriage holding twenty-four passengers, viz. sixteen inside and eight outside. The length of the body, which is in two compartments, each holding eight passengers, is 8 feet 10 inches; the width, 6 feet; and the height, 5 feet 3 inches. The outside seats are on the same level as those within; the one being in front, and the other behind: these seats are each 13½ inches wide. The whole length of the carriage, from end to end of the sole, is 14 feet 2 inches; the wheels are four in number, each 2 feet 6 inches diameter: the weight of each pair of wheels is 7 cwt. These carriages, although of unsightly appearance, are of useful form for a railway worked by horses; but not suited for high velocities, on account of the outside seats. The cost of these carriages is stated to be 50*l.* each.

Previously to November 1838, the passenger's fare was at the rate of one penny per mile; but was raised in consequence of the Government duty to 8*d.* per six miles, or 1·333*d.* per mile.

ANNUAL COST. — Mr. Moffat, the engineer of this line, states the annual

cost of keeping the way in order to be 50*l.* a-mile. There are twelve way-men employed in this service, each at 13*s.* a-week; besides these, there are two watchmen, each at 12*s.* a-week: two collectors, each at 45*l.* per annum; two coach-drivers, each at 13*s.* a-week; and a stable-keeper, at 14*s.* a-week.

The main line from Kilwinning to Ardrossan now forms, as it were, a branch of the Ayrshire Railway. Two locomotive engines, on Bury's construction, have been ordered of Messrs. Barr and M'Nabb of Paisley, to work this part of the line; they have 12-inch cylinders and 18-inch stroke, and do not exceed 8 tons in weight. The cost of each, including tender, is 1150*l.*

The number of passengers travelling on this line in the year 1838 amounted to 33,415, or at the rate of nearly 107 per diem (exclusive of Sundays); the receipts for which period, including parcels, &c., amounted to 590*l.* 17*s.* 6*d.*

AYLESBURY RAILWAY.

THE vale of Aylesbury has long been celebrated for the luxuriance of its pastures, and for the excellent produce of its farms, which has for a considerable period found its way regularly to the markets of London; but the old mode of conveyance, so slow and so expensive, was likely to limit the supplies from this quarter. It was no unusual occurrence, before the opening of this railway, for more than three days to be occupied in the passage of a drove of beasts from Aylesbury to London. Most persons are aware how much injury is done to cattle by driving them along the common road, besides the actual loss sustained by a reduction of their weight. This may be mentioned as one of the numerous advantages gained by the formation of the Aylesbury Railway, which branches off from the London and Birmingham line at a point about 35½ miles from London, making the whole distance between London and Aylesbury 42½ miles.

This railway, after leaving the London and Birmingham line with a curve of about twelve chains radius, proceeds in nearly a direct course to its terminus at Aylesbury. The worst inclination is at the junction with

the London and Birmingham Railway, where the terminal plane descends from that line at the rate of about 1 in 118, for a length of about seven furlongs.

PERMANENT WAY, &c.—This railway is laid to the English standard gauge, viz. 4 feet 8½ inches. Although the land taken is wide enough for a double way, being about 17 yards, there is at present only one pair of rails laid down from end to end. It is one of the rare instances of a railway being constructed entirely without river, road, or other bridges, which is owing to its peculiar locality; but there are five level road-crossings, and three of these are highways, which are furnished with folding gates, each 9 feet long, shutting both across the railway and roads, according as they are required.

The earthworks are slight throughout, the level of the railway being very little above the surface of the adjoining lands; the ballasting consists of chalk mixed with flints; loam is also partially used for this purpose.

The fencing through the lands consists of stout posts and five rails. The Aylesbury station is enclosed with close wooden fencing and brick walls.

The rails are chiefly of the parallel form, similar to those used on the London and Birmingham way (see Plate III. fig. 3): they are in 16 feet lengths, and fixed in chairs by means of wooden keys; the chairs are placed 4 feet from centre to centre along the line of railway; the sleepers are from 9 to 10 feet in length, and of full scantling. Open lateral drains, and cross tile-drains 6½ inches internal diameter, add greatly to the security of the works.

The station at Aylesbury is conveniently laid out: a triple way, connected, at a convenient distance from the offices, with the main line, runs into a railway-dock 33 feet wide at its entrance, and 12 feet at its connexion with the terminal turn-table, the side space of which is 4 feet 10 inches; the height of the quay, which has a curved batter of 2½ inches, is 3 feet 4 inches; the quay on either side is about 10 feet in width. There is a carriage-dock 10 feet 8 inches in length, and 8 feet 10 inches wide, furnished at its entrance with a proper turn-table, and abutting on the yard, conveniently situate for the arrival of common-road vehicles; the arrival-door for passengers is at the booking-office, on the left side of the railway as you approach Aylesbury;

the departure-gate is on the right side: for the whole length of the station there is a siding for carriages when not in use.

The booking-office and general waiting-room are in one; there is, however, a separate room for ladies. This is, upon the whole, one of the best-arranged stations for a short line of railway that we have any where met with. There is a locomotive engine-house at each end of the line; that at Aylesbury is about 100 feet in length, and 16 feet in clear width. On the top of this building is a capacious tank for water, for the supply of the locomotives.

This railway being leased to the London and Birmingham Railway (for five years), the carriages, wagons, and engines, are in every respect the same as those used on the latter way.

The engines in use on this line are of Bury's construction, and are numbered 1 and 2 in the London and Birmingham Co.'s list. The passenger-trains usually weigh on an average about 23,000 lbs. gross; the average speed is about 24 miles an hour. There are no intermediate stations.

The original capital of the Company was 50,000*l.*; the estimate for constructing and completing the railway was 45,242*l.*, or about 6,463*l.* per mile.

Mr. Samuel Bennet, the resident engineer, estimated the annual expenses of the railway at 3,000*l.* per annum, or rather more than 428*l.* per mile.

The Act of Incorporation was obtained without any opposition, and received the royal assent on the 19th May, 1836. It empowered the Company to raise a capital in joint stock of 50,000*l.*, and by loan 16,000*l.* The line was opened to the public on the 10th June, 1839.

There are at present three trains daily from London to Aylesbury in each direction, except on Sundays, when there are only two each way.

In the summer of 1839, for the first thirteen weeks of the line being opened, the number of persons travelling on this way amounted to 5473, or about sixty a-day; the receipts for the same period amounting to 1425*l.* 15*s.*, including passengers, parcels, &c. From the 10th of June to the 31st of December of the same year, the number of passengers was 19,565·50, being at the rate of about ninety-five per day; the receipts for the same period amounting to 5637*l.* 14*s.* 3*d.*

Up to December 31st, 1839, the following sums had been paid for works, &c.:—

Earthworks, ballasting, and permanent-way materials, &c.	£18,829	10	10
Rails	6900	0	0
Chairs and turn-tables	3400	0	0
Sleepers	3709	3	0
Land and compensation	9046	19	3
Stations	934	15	7
Parliamentary Expenses	2620	17	2
Engineering, including surveyor's charges	1962	11	6
Law charges	964	12	6
Advertisements, printing, and stationery	453	0	2
Secretary's expenses	125	0	0
Interest on loans, &c.	138	13	10
	£49,085	3	10
Existing liabilities	9914	16	2
Total cost of railway	£59,000	0	0

Thus, the excess over the parliamentary estimate is 13,758*l*.

This railway was laid out and executed under the general direction of Mr. Robert Stephenson; and the works throughout appear to be constructed in a substantial, and at the same time in an economical manner.

BALLOCHNEY RAILWAY.

THE district through which the Ballochney Railway passes is rich in coal and iron; but without the introduction of railways into this part of Scotland, the mines would have remained unwrought. Now the scene exhibited daily is one of great activity: new mines are being opened; additional furnaces are springing up; and the railways hitherto laid, for the purposes, it would seem, of a light traffic, are being entirely reinstated with heavier rails and in a more substantial manner, under the general direction of Mr. M'Neill.

The Ballochney Railway is in direct communication with the Slamannan and the Monkland and Kirkintilloch lines; and through the latter with the Garnkirk and Glasgow, and also with the Wishaw and Coltness Railways.

The first Act of Parliament for the construction of this way received the royal assent on the 5th of May, 1826, by which the Company was authorised to raise a capital in joint stock of 18,431*l.*, and by loan 10,000*l.* additional; and in 1835 a second Act was obtained, empowering the Company to raise by loan an additional sum of 10,000*l.*, making a total of 38,431*l.*

The general course of this line is from west to east, commencing by a junction with a branch of the Monkland and Kirkintilloch Railway, near Kipps, and running north of Airdrie, beyond which it diverges in two directions; one line taking a course about north-east to the Ballochney coal-field, and joining the Slamannan Railway, the other curving southward into the Moffat coal-field: the whole length of the lines amounts to about six miles.

The line has hitherto been worked chiefly by horses; but lately the upper part, towards the Ballochney coal-field, and contiguous to the Slamannan way, has been prepared for locomotive engines. This portion extends over about 2½ miles, and has an inclination of 1 in 70: it is laid with a double line throughout, having 54 lbs. rails (see Plate III. fig. 4) fixed in chairs secured to stone blocks. The joint-chairs weigh each 21 lbs., and the intermediate chairs 17 lbs.

The original rails, which have been in use for upwards of ten years, weigh only 20 lbs. and 28 lbs. to the yard respectively, and are of the fish-bellied form, in 18-foot lengths. The ballasting is of broken whinstone; the fencing consists chiefly of loose stones, worth 3*s.* a-yard lineal; and where built in mortar, it costs 4*s.* a-yard.

The gauge of way is 4 feet 6 inches; the intermediate space 4 feet 10½ inches; and each of the side spaces about 5 feet in width.

There is a self-acting plane of 1200 yards in length on that portion of the line next the Monkland Railway; the lower part being a single way, the middle part double, and the upper part formed with three rails. The ascending train consists usually of four loaded wagons, and the descending train of six or seven empty wagons; the time occupied in the ascent is 3·50 minutes; the rope used is about 4½ inches circumference; the sheeves are of 14 inches diameter, and are placed at intervals of 21 feet.

There are about 270 wagons in use on this line, each weighing about 24 cwt.; the wheels are of cast-iron, 2½ feet diameter. The cost of a wagon is about 15*l.* 5*s.* The horses belong to the coal-proprietors.

BIRMINGHAM AND DERBY JUNCTION RAILWAY.

THERE are several different lines which make up the great chain of railway-communication between the metropolis and York. The Midland Counties and Birmingham and Derby Railways are, as it were, double links of this chain; the one leaving the Birmingham Railway at Rugby, and running by Leicester to Derby; and the other leaving the same railway at Hampton, and proceeding by Tamworth also to Derby, where they are both united with the North Midland Railway. The Birmingham and Derby Railway leaves the station at Hampton, on the London and Birmingham line, at a distance from the metropolis of $102\frac{1}{2}$ miles; passes thence to Coles-hill and Kingsbury; extends to Tamworth, a distance from London of $117\frac{1}{2}$ miles; thence continuing to Walton, Burton-on-Trent, and Willington, reaches the Derby station, at a distance from London of 141 miles 48 chains.

The whole length of this line, from Hampton to its junction with the North Midland Railway, is 38 miles 6 furlongs and 8 chains.

The gradients are all within the first class; there being no plane with an inclination greater than 1 in 339; the greatest inclination we allow within the range of first-class gradients being 1 in 330, or sixteen feet per mile.

The terminal planes are both level; and there are also five intermediate level planes. The whole length of level way is 4 miles 62 chains. There are 23 descending planes, amounting in length to 25 miles 7 chains, between Hampton and Derby, the worst inclination being in 339; and there are twelve ascending planes between the same points, amounting in length to 8 miles 79 chains, 1 in 348 being the steepest inclination. Some of the embankments are formed from side-cutting out of dykes parallel to the railway.

In our examination of this line we counted thirty-five bridges over the railway, forty-one bridges under, eight level road-crossings, two highway-crossings, thirty-six field or occupation-crossings, and six level footpath-crossings.

The bridges over this railway have generally semi-elliptical arches; the brickwork and masonry are well executed, although the bridges are

altogether of a less expensive character than those of the London and Birmingham Railway. The bridges across cuttings have generally three arches. There are also two extensive wooden viaducts.

At the level high-road crossings are set up gates, furnished with a red disc: the gates shut either across the road or the railway, according as required. At each of the level occupation-crossings there is also an arch 9 feet wide provided for the passage of cattle.

The rails, which were furnished by Bradley and Co. of Stourbridge, at 11*l.* 10*s.* per ton, are of the single parallel form, 57 lbs. to the yard lineal (see Plate III. fig. 5), set in chairs secured to cross sleepers in the usual way. The chairs cost 8*l.* 10*s.* per ton. Small gravel is used to a considerable extent for ballasting the way.

The drainage appears to have received due attention. Some of the subdrains are of circular form, 18½ inches long, 6½ inches clear diameter; and 8½ inches external diameter, with several perforations through which to receive the surface-water; others are 15 inches long, and 11½ inches clear diameter. The whole are made of tile-clay.

The fencing consists of stout posts and rails, chiefly four in number; but in some places five. We observed a ditch on each side of some of the fences, and the quick planted inside the fence on the railway side.

The whole width of land, on a level near the Derby station, is about 18 yards.

The English standard gauge is necessarily adopted on this line, in order to join the London and Birmingham and North Midland Railways; but a quarter of an inch is allowed on each side for the full play of wheels, so that 4 feet 9 inches is actually the clear width between rails.

STATIONS. — Besides the stations at Derby and Hampton, there are six intermediate stations; two of which, at Tamworth and Burton, are first-class, and the remaining, viz. at Coleshill, Kingsbury, Walton, and Willington, are second-class stations. At the intermediate stations convenient buildings are erected; but some of them are below the level of the railway where it is on embankment. In order to prevent the passengers crossing the rails at the stations, a communication is formed under the embankment between one side of the way and the other.

At Derby, the station being for the Midland Counties, North Midland, and Birmingham and Derby Railways conjointly is on a very large scale ; and the arrangements appeared to us, as far as we could judge from the unfinished state in which we found it in the winter of 1839, to be very complete.

At Hampton, the station is conveniently placed both for the London and Birmingham Railway, and also for this line.

There is an engine-house for the locomotives at Hampton, and another at Derby. That at Derby has been erected under the superintendence of Mr. Bakewell, architect. It is about 140 feet in length, and 43 feet wide in the clear ; three double archways at its entrance support a tank, which extends from side to side of the building, and is about 12 feet in width.

Three lines of way are provided in this engine-house. At one corner of the building is a smithy ; and close to it, on the railway side, are the superintendent's office, carpenter's shop, and store-rooms.

The water is obtained by means of a hand-pump fixed in a well, at the entrance of the engine-house, 5 feet in diameter, and 75 feet in depth.

CARRIAGES. — The carriages, both first and second class, are of neat construction and design, and are very similar to those of the London and Birmingham Railway ; there are also third-class carriages.

LOCOMOTIVE DEPARTMENT. — The locomotives used on this line have all six wheels, and are by first-rate makers : their proportions will be seen by reference to the Table No. I. of British Locomotives, in the Appendix.

There is a peculiarity in Stephenson's engines, which is deserving of notice : the driving-wheels are without flanches, as on the Sheffield and Rotherham Railway. This plan will answer very well on railways free from quick curves, the friction of the flanch of the wheel being avoided without sacrificing any amount of adhesion. Some other makers have already adopted this plan.

The coke used on this railway is from the Derbyshire coal-field ; and in consequence of the facility of conveyance by the North Midland line, is supplied at 16s. a-ton.

We found the average weight of five trains on this line, in October and December 1839, to be 71,842 lbs. ; and the average velocity to be 23·04

miles per hour. (See Table B of Results of Practical Experiments, in Appendix.) The stoppages averaged each about 2·43 minutes.

ACTS OF PARLIAMENT. — The Act for the incorporation of this Company received the royal assent on the 19th of May, 1836; it empowered the Company to raise a capital in joint stock of 630,000*l.*, and by loan 200,000*l.* On the 30th June, 1837, a second Act was obtained for extending the time of taking lands from one to two years. In the following year, a third Act was obtained for altering the line at its junction with the London and Birmingham Railway, at Hampton; and in the session of 1840, a fourth Act was obtained for making the Tamworth approach, and for other purposes, which received the royal assent on the 4th of June, and enabled the Company to raise an additional capital of 200,000*l.*

TRAFFIC, FARES, RECEIPTS, &c. — This line was opened to the public on the 12th August, 1839. The receipts per diem at first amounted, on an average, to about 95*l.*; at which time there were three trains daily in each direction. In August 1840, there were five trains down to Derby, and six trains up from Derby; and on Sundays, two down and two up trains. The average receipts amount to about 193*l.* per day, or more than double the amount received at the first opening of the line.

The fares are: — For first-class passengers, at the rate of 2·49*d.*; for second-class passengers, 1·87*d.*; and for third-class passengers, 1·40*d.* per mile.

From the opening of the line, on the 11th August, 1839, to the 31st of December of the same year, a period of one hundred and forty-two days, the total receipts for passengers, parcels, merchandise, horses and carriages, &c., amounted to 16,049*l.* 10*s.* 4*d.*; and the expenditure for the same period to 11,917*l.* 8*s.* 3*d.*, including 1835*l.* 18*s.* 3*d.* for toll to the London and Birmingham Railway Company for passing over nine miles of their line, between Hampton and Birmingham. Thus the cost of maintenance of way, locomotive power, salaries, mileage-duty, and toll, as above, amounted to upwards of *seventy-four* per cent on the receipts.

This railway has been constructed under the direction of Mr. Stephenson and Mr. Birkenshaw. The latter gentleman is the resident engineer and manager, and appears to be very assiduous in his attention to the works.

BIRMINGHAM AND GLOUCESTER RAILWAY.

THE common saying, that railway engineers' estimates are not to be relied on, can at present be applied in but small degree to the Birmingham and Gloucester Railway; for up to the present time the cost of this line has not exceeded the amount of the estimates by more than five per cent. We attribute this to the constant attention and vigilance on the part of the engineer, Captain Moorsom, who has, as all engineers entrusted with these great works should be required to do, been constantly on the way, and attended to the most minute details of every part: added to this, it may be mentioned as a peculiar feature in the execution of this work, that the whole has been divided and let in very small contracts, which, although by far the most economical way of proceeding, entails much additional labour and anxiety on the engineer-in-chief.

COURSE OF RAILWAY. — The present southern terminus of this railway is at the Cheltenham station, which is situated between the old Gloucester Road and the Queen's Road, leaving which, the line passes under the Cheltenham and Arle turnpike-road, and crossing the river Chelt, in Alstone hamlet, proceeds through Swindon parish to Brockhampton, crossing Cleeve Common Lands, and continuing on through the chapelry of Stoke Orchard and parish of Tredington; thence close to Ashchurch, which is on the right and east of Northway, just beyond which it leaves the county of Gloucester, and enters the county of Worcester, in Bredon parish; thence passing to Bredon village, and keeping to the left of the turnpike-road to Pershore, as far as Eckington, about five furlongs beyond which it crosses the river Avon by an iron bridge of three arches; thence curving, it proceeds a little to the west of Defford village, and, crossing Defford Common, passes through Besford chapelry; and, intersecting Croome Perry Wood, it continues through Pirton parish and the hamlet of Wadborough, passing to the left of Abbot's Wood, still curving through the parishes of Norton and Spetchley to Bredicot, passing to the east of the church, and also on the east side of Ravenshill and Evelench, keeping close on the side of the Worcester and Birmingham

Canal, and following nearly a direct course to the left of Upper West Fields, opposite to which it crosses the Canal, and running nearly parallel thereto on the west side, passes the British Alkali Works at Stoke Prior, and continues on to the right of Sugar's Brook, and close on the left of Rigby Chapel, intersecting the parishes of Bromsgrove and Tardibig, and passing to the right of Barnt Green and Cofton Church; thence curving through the parishes of King's Norton and Northfield, and taking a mid course between Middleton Hall and the reservoir, in the parish of King's Norton; again crossing the Worcester and Birmingham Canal at Bredon, and curving between Pine Apple and Hazlewell Hall, thence to the west of King's Heath, and passing close to Moseley, which is on the west; from whence the line is produced in a curvilinear course through the township of Bordesly, and parish of Aston, to its junction with the London and Birmingham Railway.

The Tewkesbury Branch leaves the main line at Ashchurch, and runs nearly parallel and on the north side of the Tewkesbury and Oxford turnpike-road, terminating at the station in High Street.

CURVES. — Almost from end to end this line is curvilinear; the general radius of curvature is 80 chains; the quickest curves under this radius are at the Cheltenham station, at Brockhampton, and at the Tewkesbury Branch leaving the main line.

By the Act of Parliament for the construction of this line, which received the royal assent on the 22d April, 1836, the Company were empowered to raise a joint-stock capital of 950,000*l.*, and by loan 316,000*l.*, making together 1,266,666*l.* In 1837, a second Act was obtained for the purpose of extending and altering the line, and making the branch to Tewkesbury, &c.

The following is a table shewing the lengths and inclinations of each plane of the main line, commencing at the Cheltenham station:—

Lengths of Planes.			Ratio of Inclination.	Locations.
Miles.	Chains.			
	70·36	. . . . .	ascending . . . 1 in 300	
	6·00	. . . . .	level	
	10·00	. . . . .	descending . . . 1 in 100	
1	57·80	descending . . . 1 in 300	
	19·00	level	

BIRMINGHAM AND GLOUCESTER RAILWAY.

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Lengths of Planes.		Ratio of Inclination.		Locations.	
Miles.	Chains.				
	21·00	descending	1 in 656		
1	60·87	descending	1 in 300		
	29·93	ascending	1 in 949		
1	14·61	descending	1 in 300		
	23·31	level			
	10·00 }	ascending	1 in 300	{	Aschurch station.
	51·25 }	ascending	1 in 300		Tewkesbury Branch
	29·00	descending	1 in 578		diverges.
1	7·83	ascending	1 in 300		
1	15·50	descending	1 in 300		
1	25·76	level			
	62·88	descending	1 in 1000		
	32·68	level			
	11·21	ascending	1 in 300		
	8·79	level			Defford station.
1	65·11	ascending	1 in 372		
	65·27	ascending	1 in 1000		
2	3·10	ascending	1 in 300		
	66·70	descending	1 in 833		
	38·38	level			
	34·32	ascending	1 in 300		
	22·68	level			Spetchley station for Worcester.
1	15·53	ascending	1 in 300		
	33·49	descending	1 in 500		
	37·81	level			
	41·49	ascending	1 in 397		
1	61·00	level			
	25·17	ascending	1 in 300		
	26·30	descending	1 in 681		
1	56·29	level			Droitwich station.
	20·95	ascending	1 in 300		
	42·20	level			
1	06·50	ascending	1 in 300		
	22·50	ascending	1 in 100		
1	77·18	ascending	1 in 300		
	30·00	ascending	1 in 100		
	10·00	ascending	1 in 300		Bromagrove station.
2	3·35	ascending	1 in 37		Lickey Incline.
1	06·85	ascending	1 in 300		
1	23·42	descending	1 in 300		

Lengths of Planes.		Ratio of Inclination.		Locations.
Miles.	Chains.			
	3·00	level		
	53·87	ascending . . .	1 in 300	
4	20·05	descending . . .	1 in 300	
1	22·34	level		
	26·82	descending . . .	1 in 300	
	10·00	level		
	43·74	descending . . .	1 in 400	
	32·30	descending . . .	1 in 100	
	79·71	descending . . .	1 in 305	
1	09·09	descending . . .	1 in 84	
	19·11	level		{ Junction with London and Bir- mingham Railway.

Thus the whole distance, from the Cheltenham station to the junction with the London and Birmingham Railway, is 45 miles 43·40 chains. There is a branch-line diverging from the main line at 1 mile 32·11 chains from the junction of the London and Birmingham Railway, which is 18·29 chains long, and terminates at Camp Hill, Birmingham; for 8·29 chains this branch falls at the rate of 1 in 305, and the remainder is level. The summit of the line, which is near the Lickey, is 400·73 feet above the rails' level at Cheltenham; and the level of the rails, at the junction with the London and Birmingham Railway, is 191·35 feet higher than at the Cheltenham station.

The line is divided into fifty-five planes: of which sixteen are level, and amount in length to 9 miles 28·35 chains; twenty-one ascending from Cheltenham, amounting in length to 18 miles 21·77 chains, and varying in inclination from 1 in 37 to 1 in 1000; and eighteen descending planes, whose collective length is 17 miles 73·28 chains, and the inclinations of which vary from 1 in 84 to 1 in 1000.

The Lickey Incline of 1 in 37 extends for 2 miles 3·35 chains, and is, we understand, to be entirely worked by locomotive engines.

If this is satisfactorily effected, it will throw a new and useful light on the laying out of railways, and will save a vast original outlay in future works. We have long considered that the present system of making the sixteen feet gradient the *minimum*, is far from desirable. The advantages in working a railway thus graduated are not equivalent to the immense original outlay necessarily incurred by tunnels and overwhelming earthworks.

The Tewkesbury branch is 2 miles 10 chains in length, and has eight planes, three of which are level, four inclining at the rate of 1 in 300, and one at the rate of 1 in 150 for 4·35 chains. The whole length of main line and branches is thus 47 miles 71·39 chains.

EARTHWORKS.—The strata intersected by this railway consist chiefly of marl and lias clay. The total quantity of cuttings amount to 3,660,000 cubic yards; of side-cutting, to 150,000 yards; of embankments, to 3,500,000 yards; and of spoil, to 250,000 cubic yards. The largest cutting, which is at Moseley, amounts to 750,000 yards; and the chief embankment, to 480,000 yards: the extreme depth of the former being 85 feet, and the greatest height of the latter 62 feet. The slopes of the cuttings are formed generally at $1\frac{1}{2}$ to 1; and of embankments, at 2 to 1. The average lead was about 70 chains, or seven furlongs, and the longest lead 3 miles. The contracts for the earthworks averaged about a mile and a half each. In a few cases, the work was prosecuted by night as well as by day. The works were commenced in November 1837; and the number of men employed has never exceeded 3500 at any one time.

The top width of embankments is 30 feet; and the width of cuttings between side-drains is 28 feet.

BRIDGES.—The whole number of bridges on this line is one hundred and sixty-two, besides one hundred and twenty-seven culverts. They are built of brick, of stone, of stone and iron, and some of wood. The span of arches over the railway is 23 feet; and the arches under the railway vary in span from 16 feet to 48 feet. The occupation-arches under the railway are each of 12 feet span.

There is a particular description of lattice-work wooden bridge used on this railway, which, we understand, was introduced from America by Mr. Hughes, the resident engineer; one of these we observed over a cutting near Bredon, which is about 117 feet in span, $17\frac{1}{2}$ feet wide in the clear, about the same height, and 200 feet in extreme length.

The roadway planking is supported by transverse joists about 6 feet below the top rail of framing. These joists are placed about 3 feet from centre to centre, and have a bearing on each side on the middle rail, or

band, which runs from one abutment to the other. Besides this band, there are two superior and two inferior bands, running the whole length of the lattice-work. Each end of the framing has a bearing on cross sleepers bedded in the solid ground in proportion to the span, and is let into a pedestal at each end. Beneath the level of the roadway, the lattice-work framing on each side is connected together with cross ties and braces, both of wood.

In order to give this bridge a horizontal appearance, the longitudinal timbers should have a slight camber. One of these structures, on our view of this railway, appeared to have sunk considerably in the middle.

The largest bridge is that which carries the railway over the river Avon, near Eckington. It consists of three cast-iron segmental arches, each of 73 feet span, and supported upon two lines of iron columns resting on iron caissons filled with masonry. The ribs and other castings of which this bridge is composed are not so slightly as they might have been; and the iron railing is of too studied a design for such a work. The whole length of this bridge is about 270 feet, and the clear width 23 feet. The total cost is stated to have been 10,000*l*. There is only one tunnel throughout this line, which is carried through Grovely Hill, near the Lickey, Bromsgrove. This is at the summit of the railway, and is only a quarter of a mile in length; the extreme depth of rails from the surface of ground being 86 feet. The arch is of semi-circular form. The whole is constructed of brick-work, but the side walls rest on independent footings, there being no invert. The vertical shafts used for executing the work are nine in number, and each 8 feet in diameter. The whole were worked by horse-gins. This tunnel is on a curve of a mile radius, and the cost per lineal yard is stated to have been 32*l*.

LEVEL CROSSINGS.—There are no level turnpike-road crossings throughout the line; but there are eighteen level high-road and lane crossings, about forty field or occupation-crossings, and about ten level footpath crossings. Where gates are fixed at the level road crossings, they are hung to shut across the roads only.

GAUGE OF WAY, &c.—The gauge of way is 4 feet 8½ inches; the intermediate space on embankments 6 feet; and each side space 7 feet 3½ inches wide.

It is a peculiar feature of this line, that although the rails are not laid throughout on longitudinal sleepers, there is an entire absence of stone blocks. This plan is gaining ground every day; and on some lines we have known sleepers substituted to a great extent for stone blocks, which had been originally introduced at great cost.

The rails used are of two different sections (see Plate III. figs. 6 and 7), and may be termed of the shallow parallel form, having a thick bottom web bevelled off at the sides. The weight, per lineal yard, is 56 lbs. The rails were supplied by Forsters, of Stourbridge, at 12*l.* 12*s.* 6*d.* per ton. The rails are set with 2½-feet bearings, in intermediate and joint chairs, on embankments, and secured thereto by wooden keys.

In cuttings, the chairs are 5 feet apart, with intermediate saddles. The size of an intermediate chair is 5 inches by 4 inches; and the size of a joint chair is 7 inches by 4 inches; the weight of the former being 18 lbs., and of the latter 24 lbs.

The saddles are 5 inches by 3½ inches thick, and spiked to the longitudinal sleepers. The weight of a saddle is 3 lbs.

Parts of the way are laid with longitudinal, and parts with cross sleepers; the cross sleepers being used on embankments above 5 feet in height. The longitudinal sleepers are of American pine, in lengths of from 15 to 60 feet; the scantling averaging about 13 inches by 6 inches. The cost of these timbers, kyanized, is 2*s.* 2*d.* per cubic foot, on the way. The longitudinal sleepers are connected together with ties 7 feet 2 inches long, and measuring 7 inches by 3½ inches, being half-round logs. The chairs are secured to the longitudinal sleepers by ¾-inch screw-bolts and nuts. The bolts are of various lengths, viz. 6½ inches, 8½ inches, 10½ inches, and 12½ inches.

The cross sleepers are of beech or larch kyanized, 8 feet long, 10 inches wide, and 5 inches thick, being half-round logs. The cost is stated at from 1*s.* 6*d.* to 1*s.* 9*d.* per cubic foot, at various parts of the line.

The ballasting is of the width of 28 feet, and 22 inches in thickness. There are no less than seven different descriptions of ballasting; viz. burnt clay, burnt marl, gravel, sandstone, cinders, rock marl, and broken stone. The burnt clay and burnt marl cost from 1*s.* 2*d.* to 2*s.* 6*d.* per cubic yard; the gravel and sandstone from 6*d.* to 1*s.* 6*d.*; the cinders from 2*s.* 6*d.* to 3*s.*; and the rock marl and broken stone (lias and oolite) from 9*d.* to 5*s.* 6*d.* per cubic

yard. So many descriptions of ballasting, and so many different prices, cannot be heard of in the history of any other railway.

Besides the culverts, there are various descriptions of drains, as open cuts, earthen pipes, rubble-stone, gravel, and fascines, the cost of which varies from 1*s.* 2*d.* to 5*s.* per lineal yard.

A great proportion of the way is fenced in with posts and three rails, and quick; but iron wire is, in some instances, introduced between stone piers; and walls are occasionally to be met with.

THE STATIONS.—The stations at present fixed are those of Cheltenham, Ashchurch, Spetchley, Droitwich, and Bromsgrove, which are all first-class stations; and the second-class stations are at Bredon, Eckington, and Defford.

The station at Cheltenham, which is situated on the surface of the ground, the railway being in 15-foot cutting, is built of the Grecian-Doric order, with a colonnade extending along the whole front next the Queen's Road; above which is a water-tank of co-extensive dimensions, for the use of the locomotive engines. The entrance to the offices from the railway is approached by two flights of stone steps. The apartments consist of a booking-office, refreshment-room, secretary's room, and engineer's office, with other conveniences, besides several apartments on the upper floor.

The railway at this station is entirely covered with a wooden span roof, supported on iron columns, and covered with slates. It is to be observed, that in this roof are formed two bridges, for the purpose of passing from one side of the way to the other. Detached from the general offices is a stationary pumping engine-house, an engine and carriage shed, and stables for about five horses.

The station at Bromsgrove, on a smaller scale than that at Cheltenham, is entirely in cutting, about ten feet in depth, and has a sloped approach from the Bromsgrove Road, which passes in the rear of the station-house, and between the workmen's cottages and goods-shed, returning back by another gateway into the same road. The offices consist of a booking-office, clerks' office, secretary's room, passengers' waiting-room, ladies' waiting-room, and resident engineer's office, with the usual conveniences. In front of the building, which is one story high, is a colonnade extending the whole length. The design has, upon the whole, a pleasing and unostentatious appearance. The

passenger-platform is 10 feet wide, and 18 inches high above the surface of the rails. At this station there is an additional line of way, for the use of the engines employed in assisting the trains up the Lickey Incline.

The buildings of the intermediate stations are erected in the Gothic style, very much like those on some of the Scotch railways recently opened to the public. An intermediate station-house on this railway consists of about four rooms, including a booking-office and waiting-room.

CARRIAGES.—The carriages are shewn in detail in Plate XIII. The first-class carriages have each two whole compartments in the middle, with a coupé at each end. The middle compartments will each hold six persons, and each coupé three; altogether eighteen. These smaller compartments will, no doubt, be generally sought after by invalids, and ladies travelling alone. The length of a first-class carriage is 17 feet 6 inches, and extreme length, including buffers, 21 feet 6 inches; the width of the body is 7 feet, and extreme width, including steps, 8 feet 6 inches. The clear height of the body is 5 feet 1 inch; the height of the body and under-carriage 6 feet; and the extreme height from surface of rails 7 feet 8½ inches. Each of the middle compartments is 5 feet long and 6 feet 10½ inches wide, both in the clear. The seats are 1 foot 8 inches wide, and 1 foot 6 inches high from floor to top of cushion. The seats are separated by elbows in the ordinary way. Each coupé is 3 feet 4 inches long, and 6 feet 10½ inches wide; both in the clear. The carriage-doors are each 1 foot 9 inches wide, and 4 feet 7 inches high. Besides the sash in each door, there are fixed side-lights, corresponding in height with the sash, and 9 inches wide; the lower part being of quadrant form. Some of the first-class carriages are furnished with imperials on their roofs, which are 8 feet 6 inches in length, 5 feet in width, and 2 feet in height.

The under-carriage consists of two open soles, the whole length of the carriage, 12 inches deep and 3 inches thick, firmly secured at angles with corner-plates; four cross timbers framed into the lower part of the soles, and having a scantling of 5 inches by 3 inches; and four diagonal braces of wrought iron, 2 inches by ½ inch, each brace running from one of the angles to the middle of the opposite sole. The buffers and draw-bar are on the spiral-spring principle; the distance between centre and centre of buffers is 6 feet,

and the height of horizontal centre line of buffers, with loaded carriage, 2 feet $2\frac{1}{2}$ inches above rails. There is a double brake apparatus fitted between each pair of wheels, and worked by a system of levers fixed to the under-carriage, and an upright rod terminating in a handle by the guards' seat at the end of the carriage.

There are altogether nine plate-iron steps, fixed on the outside of each sole, measuring 11 inches by 8 inches, except two of the higher end steps at opposite corners, which are about 9 inches by 8 inches. A wooden foot-board, the whole length on each side, is, however, fixed on some of the carriages, and is far preferable. Most of the railway carriages in the north of England, and also in Scotland, are furnished with footboards.

The carriages of this railway are all hung low, as those of the Greenwich, and Newcastle and Carlisle railways. The wheels are generally from the works of Bramah and Fox, of Birmingham, of their patent or loop form, 3 feet in diameter, the distance between the centres of axles being 10 feet. The springs are fastened to the inside of soles, and are 4 feet 8 inches in length, taken from point to point horizontally, the bed of spring being 6 inches below the centre of wheel.

The carriages are painted a dark buff, picked out with black; and the arms of the Company are emblazoned on the middle doors.

The second-class carriages are in three compartments, in the usual way; but have the advantage of being closed at the sides. Each compartment will hold eight persons, or twenty-four in the whole. The compartments are open to each other above the dwarf partitions, the tops of which are 13 inches above the seats; the roof being supported intermediately by iron standards, one of which rests on each partition. The length of a second-class carriage is 15 feet 6 inches; and extreme length, including buffers, 19 feet 6 inches. The width of the body is the same as the first-class carriage, viz. 7 feet; and the extreme width, including steps, 8 feet 6 inches. The clear height is 4 feet 11 inches. The under-carriage corresponds with that of the first-class in point of structure and general arrangement; but the wheels, instead of being 10 feet, are only 6 feet 6 inches from centre to centre of axles.

Besides the first and second-class, there are a few third-class carriages, for the accommodation of the poorest class of travellers; these are without seats.

In the centre portion is a closed compartment for luggage, the standing berths being at each end.

WAGONS.—There are two descriptions of wagon used on this line, viz. those for ballast and those for goods (see Plate XIV.). The ballast-wagons, about sixty in number, weigh each about two tons, and the cost is stated at from 63*l.* to 68*l.* each. The length of a ballast-wagon is 10 feet 3 inches, the width 7 feet 9 inches, and the height 1 foot 5 inches. Both sides and ends are hung with stout iron hinges to let down; and secured, where required, at corners with iron eyes and catches. The under-frame is of the ordinary construction. The wheels are of cast iron, 3 feet in diameter, and 4 feet 8 inches from centre to centre of axles.

The goods-wagons are each 10 feet 3 inches in length, 7 feet 9 inches in width, and 3 feet 5 inches in height. The sides and ends are formed of five rails secured to oak ledges let into iron sockets, fixed on the outside of the bottom plank or skirting. The rails are bound at the corners with angle-ties. The under-carriage and wheels are the same as those of the ballast-wagons. Each goods and ballast-wagon is furnished with a single lever brake, and wrought-iron draw-bar.

LOCOMOTIVE ENGINES.—There are at present twelve locomotive engines in use on this railway, eight of which were built by Mr. Norris, of Philadelphia, and present a novel appearance (see Plate VI.). They have outside sloping cylinders 10½ inches diameter (except one, which has cylinders of 11½ inches), and 18-inch stroke. The piston-rods work outside the wheels. The driving-wheels are 4 feet in diameter; and the four bearing-wheels, which are attached to a truck-frame called a *bogie*, turning on a pivot for the purpose of easing the engine round curves, are each of 2 feet 6 inches diameter, and 3 feet from centre to centre of axles. These bearing-wheels are placed in front of the engine, under the smoke-box: the distance between the axle of the driving-wheels and that of the hind pair of bearing-wheels is 6 feet 4 inches. The number of tubes in each engine is 78; the length 8 feet; and the external diameter 2 inches. The net weight of an engine is 8 tons; and with the boiler and fire-box full of water and coke, 9 tons 11½ cwt. The chimney is 6 feet 9 inches above smoke-box, and 13 inches in diameter. The whole

length of an engine is 18 feet 4 inches; the width 7 feet 2 inches; the height from surface of rails to top of boiler 6 feet; the height from rails to top of chimney 12 feet 9 inches. The fire-box is round, and similar to that of Bury's engine (see Plate VI.).

Four of the above engines are called the England, the Philadelphia, the Columbia, and the Atlantic. The price of one of these engines complete, including the import duty of 20 per cent, is from 1500*l.* to 1600*l.*

In a paper by Captain Moorsom, read before the Institution of Civil Engineers on the 7th of April last, relative to the performance of these engines on the Grand Junction Railway, he states, that "on a plane of 1 in 330, with a load varying from 100 to 120 tons, the speed varied from 13·80 miles to 22·50 miles per hour; that on a plane of 1 in 177, with a load of 100 tons, the speed varied from 9·80 miles to 13·80 miles per hour." He further adds, "A comparison of the journeys up from Liverpool to Birmingham, with those down from Birmingham to Liverpool, gives rather a singular result. The aggregate rise of the planes from Liverpool to Birmingham is about 620 feet; and from Birmingham to Liverpool about 380 feet, (exclusive in both cases of the Liverpool and Manchester Railway). The difference, therefore, up to Birmingham is about 240 feet. In seven journeys of 596 miles up to Birmingham, the engine conveyed 682 tons gross, evaporated 12,705 gallons of water, and consumed 177 sacks of coke (1½ cwt. each). In seven journeys of 596 miles down from Birmingham, the same engine conveyed 629 tons gross, evaporated 12,379 gallons of water, and consumed 177 sacks of coke."

Thus the consumption of coke, according to this statement, taking the average of the loads up and down, was at the rate of only ·007 lb. per ton per mile!! The extreme limit of working pressure in the boiler was 62 lbs. per square inch.

There are four engines made by Forrester and Co., of Liverpool; they are called the Cheltenham, the Worcester, the Bromsgrove, and the Tewkesbury. These have 13-inch cylinders, 18-inch stroke, 5½-feet driving-wheels, 4-feet front wheels, and 3-feet hind wheels. The cylinders are outside, and fixed into the framing; the cranks being outside and wheels inside the bearings. The fire-boxes are of copper; and the tubes of brass, 130 in number, and of 1½ inches diameter. The whole weight of one of these engines, in working trim, is 12 tons 5 cwt.

Besides the above, there are three old ballast-engines forming part of the Company's stock.

The tenders are fifteen in number; and are calculated to hold each from 520 to 700 gallons of water, and one ton of coke. The weight of a tender with complement of fuel and water is stated to be $5\frac{1}{2}$ tons.

The principal locomotive station is at Bromsgrove. The engine-room has one line of way, with engine-race from end to end. Over this race, or pit, is a movable turn-table, for the purpose of transferring engines to any of the six transverse lines. Contiguous to the engine-room is the smithy; and beyond it, on the same line, is the brass-foundry. The whole length of this portion of the building is 172 feet, and the width about 60 feet. The line of way running along the engine-room is produced quite through the building, and separates the turnery and stationary engine-room from the smithy and brass-foundry. This part of the building is about 71 feet in length, and about 35 feet in width.

The following is a statement of the different items of expenditure, from the commencement of the undertaking up to 31st December, 1839 :—

Works	£370,400 16 11
Land	119,179 6 3
Engineering	26,384 10 2
Parliamentary expenses	21,992 14 7
Tram-road shares	17,500 0 0
Stock	12,968 8 9
Surveying and conveyancing	12,527 18 5
Compensation	9,671 2 3
Office-charges and salaries	6,447 16 7
Deputation and travelling expenses	3,025 15 2
Direction	2,740 15 9
Law-charges	2,266 17 11
Advertisements	1,125 16 9
Police-establishment	569 16 2
Furniture and fixtures	509 1 9
Stamps, &c. for debentures	456 4 3
Incidental expenses	286 14 11
Rates and taxes	24 15 3
	<hr/>
	£ 608,078 11 10

This railway was opened for traffic between Cheltenham and the Bromsgrove station on the 24th June, 1840, with two trains daily in each direction; and on the 8th July following, three additional trains were put on in each direction: the fares for first, second, and third-class passengers, between Cheltenham and Bromsgrove, being respectively 8s., 5s. 6d., and 3s. 6d. The amount received on an average per diem for passengers, carriages, and horses, in August 1840, is about 160*l*. There are at present no trains on Sundays.

BISHOP AUCKLAND AND WEARDALE RAILWAY.

THE introduction of railways, in a commercial point of view, has, perhaps, done as much for the county of Durham as for any other equal extent of country. The quantity of coal annually shipped from the rivers Tyne and Wear, all of which is brought down from the collieries by railway, is sufficient to warrant the above remark.

The Bishop Auckland and Weardale Railway, which branches off from the Stockton and Darlington line close to the Black-boy Branch, is a new link in the great Durham Railway chain, and runs in a direction nearly parallel with that branch to the Deanery Colliery Railway, which it crosses about 7 chains west of the Black-boy Branch; it thence continues to Holdforth, and passing between Bishop Auckland and Blue Row, proceeds in a direction west by north, and on the north of Woodside; thence, with a curve of about 50 chains radius, falls into a direction nearly north, crossing in its course the river Wear; and twice crossing the old river, and passing near to Howden, and on the west of High Bitchburn, terminates at the road from Wolsingham, in the township of Crook.

The most objectionable curves are of not less than half a mile radius.

The following is a table of the gradients, commencing at junction with the Stockton and Darlington Railway:—

Miles.	Chains.		Gradients.
	14·36	ascending at the rate of . . .	18·33 feet per mile.
2	62·00	descending at the rate of . . .	22·73 feet per mile.
	78·00	ascending at the rate of . . .	10·00 feet per mile.

Miles.	Chains.	Gradients.
1	45·00	descending at the rate of . . . 9·66 feet per mile.
	60·00	level
1	03·00	ascending at the rate of . . . 30·00 feet per mile.
1	13·00	ascending at the rate of . . . 123·20 feet per mile.
	10·83	level to turnpike-road from Wolsingham to Durham.
<u>8</u>	<u>26·19</u>	

The whole length of this line, therefore, is 8 miles and 26·19 chains.

The gradients, it will be seen, are very favourable, except for one plane towards the north end of the line, which is one mile and thirteen chains in length, and rises at the rate of 1 in 42·85, the gradient being 123·20 feet.

EARTHWORKS, BRIDGES, &c. — Among the chief earthworks may be mentioned the Denburn Brook embankment, which is 52 chains in length, and 48 feet above the brook. This work is partly formed from the produce of the tunnel;—Etherley Dean Brook embankment, which is 71 feet above the brook, but is only 9·25 chains in length;—the river Gaunless embankment, which is 78 feet above the river at the highest point, and 17 chains in length;—and the river Wear embankment, which is about three quarters of a mile in length, and averaging about 50 feet in height.

The tunnel, which is at present in progress, and let to several contractors, is intended to be 62 chains in length, 25 feet in height, and of width sufficient for a double way: the greatest height of ground above the surface of rails is 118 feet. The south face of the tunnel will be $43\frac{1}{2}$ chains from the centre line of the Stockton and Darlington Railway.

There are fifteen bridges and culverts for roads, rivers, &c., to pass under the railway; and six bridges for roads to pass over the railway. The Holdforth embankment culvert may be mentioned as one of the principal works in this department: it is $242\frac{1}{2}$ feet long, 34 feet in span, and 18 feet high. The masonry of the arch, which is of sandstone, is 4 feet in thickness; the abutments 10 feet in thickness, and backed with ten contreforts, each $6\frac{1}{2}$ feet wide. The masonry of this culvert will cost nearly 11,000*l*.

The gauge of way is the same as the English standard, viz. 4 feet $8\frac{1}{2}$ inches.

The top width of embankments is 28 feet, which is the same as on the Stockton and Darlington line.

The rails are of the parallel form, weighing 50 lbs. to the yard, and are from the celebrated works of Messrs. Guest and Co. of Dowlais. Stone blocks are to be used throughout.

The royal assent was given to the Act of incorporation on the 15th of July, 1837; it empowered the Company to raise a joint-stock capital of 72,000*l.*, and an additional sum by loan of 24,000*l.*, making together 96,000*l.*

BODMIN AND WADEBRIDGE RAILWAY.

THE county of Cornwall, till of late years, was but ill supplied with the means of internal conveyance for the valuable products of its numerous mines. The minerals were either transported on the backs of mules, or in rough carts over rugged cross roads. In the principal mining districts, single lines of railway were laid down some years ago, which have hitherto been entirely worked by horses; but the opening of the Bodmin and Wadebridge Railway introduced into the county of Cornwall that splendid triumph of art, the locomotive engine, without which railways to this day could have been considered only as improved turnpike-roads.

It is, perhaps, not generally known, that in many parts of Cornwall sea-sand is, to an amazing extent, used as a valuable dressing for the lands.

In the districts bounding each bank of the river Camel, the lands have, from a very early date, been supplied with sand from its entrance at Padstow, which has also been conveyed inland to distances of from twelve to fifteen miles, although at a cost for transport by the common roads almost precluding its use. By means of the Bodmin and Wadebridge Railway, a portion of which was opened to the public on the 4th of July, 1834, and the remainder on the 30th of September of the same year, this valuable manure is now readily supplied to a large extent of country.

Sir William Molesworth, at his own cost, employed Messrs. Hopkins to report on the then proposed railway in 1831; and in the following year, a Company having been formed, an Act was obtained for its construction, which occupied about eighteen months.

At Wadebridge, which is situate close to the river Camel, and up to which place the river is navigable for vessels of 150 tons burden, is the commencement of this railway, which runs thence nearly parallel to the river as far as Wentford bridge, a distance of twelve miles; a branch-line connects it with Bodmin, of about $1\frac{1}{2}$ miles in length. There is also a branch to Ruthern bridge, of about a mile in extent.

INCLINATIONS, &c. — The inclinations, commencing at Wadebridge, are as follows:—

$2\frac{1}{2}$ miles	. . . . .	rising 1 in 3168 to Polbrook.
8 miles	. . . . .	rising 1 in 226 to Tresonett.
$1\frac{1}{2}$ miles	. . . . .	rising 1 in 144 to Wentford bridge.

The inclination of the Bodmin Branch is 1 in 51; and that of the Ruthern Branch 1 in 158.

The gauge is 4 feet $8\frac{1}{2}$ inches, and the side-spaces vary from 4 feet 6 inches to 6 feet 6 inches each.

The excavations and embankments are as much at some points as from 23 to 27 feet in depth and height respectively.

A single way is laid throughout with numerous sidings.

The width of the excavations at level of rails is 14 feet; and of the embankments 18 feet.

The fencing consists of earthen mounds paved with stone and turfs, and also of hedges. The blocks for the support of the rails are of granite, about 12 inches thick and 20 inches square; the cost of each being only eightpence. At the joints, there are occasionally through blocks 6 feet in length, laid across from rail to rail. The joint-chairs, of cast iron, are 12 lbs. each in weight, and the intermediate $10\frac{1}{2}$ lbs. The rails are of the parallel form, in from 15 to 18-feet lengths, and weigh 42 lbs. per yard; they are secured to the chairs by wedges. The rails, from Ebb Vale and other iron-works, cost from 8*l.* to 10*l.* per ton.

There are eight bridges crossing the Camel, and other rivers, besides several culverts. One of the bridges, which is across the Treguddick river at Wadebridge, is of the ordinary turning construction, and 18 feet in span. There are also over the same river two counterpoise bridges, also of 18 feet span each. These bridges are each raised and lowered by four counterweights, weighing altogether 3 tons; each weight is suspended within a cast-iron hollow column, two being placed at each end of the bridge, with a pulley-wheel on the top for the chain to run on.

The other bridges are built either of wood and stone, or of granite.

At the Wadebridge terminus there is a dock capable of admitting six vessels, which may discharge their cargoes at the same time. There is also another dock, constructed at the expense of Sir W. Molesworth, capable of holding twenty sand-barges at a time. Along the line are several sand-depôts, where, by means of wooden stages, the sand is readily discharged through trap-ways from the railway-wagons.

LOCOMOTIVE DEPARTMENT.—The traffic is carried on entirely by two locomotive engines called the Camel and Elephant, constructed by the Neath Abbey Iron Company. The Camel has 6 wheels, each of 3 feet 10 inches diameter; $10\frac{1}{2}$ -inch cylinder; 24-inch stroke; 38 tubes, each 4 feet 10 inches long, and 3 inches diameter; fire-box, 54 inches long, 42 inches wide, and 16 inches high; boiler, 11 feet 6 inches long, and of 4 feet 6 inches diameter; chimney, 7 feet 10 inches high, and $12\frac{1}{2}$ inches diameter; steam-passage, $3\frac{1}{2}$ inches diameter; blast-pipe, $2\frac{1}{2}$ inches diameter; net weight, 10 tons; weight, with fuel and water, $12\frac{1}{2}$ tons; and cost, including tender, 725*l*.

The Elephant is altogether a larger machine, and has also six wheels, each 3 feet 10 inches diameter; cylinder, $12\frac{1}{2}$ inches diameter; length of stroke, 24 inches; 65 tubes, each 26 inches long, and 3 inches diameter; fire-box, 50 inches long, 42 inches wide, and 16 inches high; chimney, 9 feet 4 inches high, and 15 inches diameter; steam-passage, 4 inches diameter; blast-pipe, 2 inches diameter; net weight of engine, 12 tons; weight of engine, with fuel and water, $14\frac{1}{2}$ tons; cost, including tender, 800*l*.

The tenders are calculated each to hold 370 gallons of water and one ton of coals; the weight of each, with fuel and water, is $5\frac{1}{2}$ tons.

Tredegar coal is wholly used on this line, and costs 16*s.* 6*d.* per ton.

There are seven water-stations along the whole line : the water used is of good quality, and does not cost the Company more than 35*s.* a-year.

The usual working-pressure is 50 lbs. on the square inch. Mr. Hopkins informs us, that on the rise of 1 in 144, the engine draws, at the rate of six miles an hour, ten wagons, each weighing 30 cwt., and containing together 50 tons of sand, making the gross load 145,600 lbs., or 65 tons. On the Bodmin Branch, which rises 1 in 51, the engine takes up four loaded wagons, equal to 58,240 lbs. gross.

CARRIAGE DEPARTMENT. — There are two carriages for the conveyance of passengers ; one for the first class, and the other for the second class. The first-class carriage holds forty-two persons, is 12 feet in length, 6 feet wide, and 7 feet in extreme height ; the wheels are of cast iron, and 3 feet in diameter : the weight of this carriage is 2 tons. The second-class carriage is 9 feet long, 6 feet wide, and holds sixteen persons. Both carriages were built by the Company.

The number of persons travelling on this railway in 1838 amounted to 3274 ; and the receipts on this account to 88*l.* 2*s.* 3*d.* The fares for first-class passengers are 1½*d.* per mile ; and for second class, 1*d.* per mile ; but if passengers return on the same day, they are charged only half fares. The amount of duty paid to Government averaged for four years 14*l.* 4*s.* 7*d.*

The wagons for ores, &c., are thirteen in number ; the wheels are of 22 inches diameter ; and the net weight 30 cwt. ; the cost of a wagon being 13*l.* The coal and sand-wagons are twenty-seven in number, the wheels of which are 3 feet in diameter, and the weight, 2 tons ; the cost being 30*l.*

Lanterns are the only signals used on this way.

ANNUAL CHARGES. — There are five waymen constantly employed ; one engine-driver, at 21*s.* a-week ; a fireman, at 15*s.* a-week ; two coke and water-fillers, at 12*s.* a-week each ; two smiths' apprentices ; and one carpenter. There is also a superintendent and one assistant.

ACTS OF PARLIAMENT, &c. — The Act of incorporation received the royal assent on the 23d May, 1832, and empowered the Company to raise a joint-stock capital of 22,500*l.*, and an additional sum by loan of 8000*l.* A second

Act was obtained on 30th July, 1835, by which power was given to the Company to raise an additional sum by loan of 5000*l*.

The total cost of the railway, including two Acts of Parliament, two locomotive engines, and forty wagons, amounted to 35,498*l*. 2*s*. 9*d*., which is at the rate of only 2450*l*. per mile.

BOLTON AND LEIGH, AND KENYON AND LEIGH JUNCTION RAILWAYS.

So long back as 1825, an Act of Parliament was obtained for making a railway or tram-road from or near the Manchester, Bolton, and Bury Canal, in the parish of Bolton-le-Moors, to or near the Leeds and Liverpool Canal, in the parish of Leigh. In this Act, however, there is no mention of the amount of capital required to carry it into execution. In 1828, a capital of 25,000*l*. in joint stock was authorised to be raised by the second Act, which received the royal assent on the 26th of March. Two subsequent Acts have been obtained by this Company; the one dated 30th July, 1831, authorising an addition to be made to the joint-stock capital, of 16,500*l*. and empowering the Company to raise by loan 25,000*l*.; and the other, which received the royal assent on the 20th May, 1836, giving the Company power to borrow 60,000*l*. additional.

Besides the above, an Act authorising the extension of this railway from Leigh to the Liverpool and Manchester line at Kenyon, was passed in the session of 1829, and enabled the Company for the purposes of the Act to raise 31,250*l*., of which 25,000*l*. was to be in joint stock, and the remainder by loan.

This line is leased to Mr. Hargreaves, of Bolton, who finds locomotive power, carriages, and wagons, except a few for ballasting which belong to the Company.

With the exception of about half a mile, which is towards the north end of the line, the whole is laid with a single way, and occasional sidings

or passing places; the distance from Kenyon Junction to Bolton being 9 miles 6 furlongs.

According to Mr. Bradshaw's book of levels, the following is a statement of the inclinations, commencing at Kenyon:—

Miles.	Chains.	Links.		Ratio of Inclination.
1	19	78	. . . . .	descending . . . 1 in 528
	56	45	. . . . .	level
	33	50	. . . . .	ascending . . . 1 in 100
	2	00	. . . . .	descending . . . 1 in 100
	8	65	. . . . .	level
	63	55	. . . . .	ascending . . . 1 in 491
1	40	15	. . . . .	ascending . . . 1 in 82
	10	55	. . . . .	ascending . . . 1 in 1341
	2	63	. . . . .	ascending . . . 1 in 127
	4	45	. . . . .	ascending . . . 1 in 49
1	15	27	. . . . .	ascending . . . 1 in 30
2	9	65	. . . . .	ascending . . . 1 in 425
	21	65	. . . . .	descending . . . 1 in 222
	16	65	. . . . .	descending . . . 1 in 43
	10	27	. . . . .	descending . . . 1 in 55
	31	05	. . . . .	descending . . . 1 in 33
	4	27	descending . . . 1 in 38
	15	37	descending . . . 1 in 277
	6	92	ascending . . . 1 in 660
	7	50	descending . . . 1 in 153
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	9	60	31	

It will be seen by reference to the above table, that there are 3 miles 42 chains with inclinations varying from 1 in 30 to 1 in 82; the whole number of planes being twenty, of which nine are ascending towards Bolton, nine descending, and two level.

BRIDGES, &c. — The number of bridges, which are constructed of brick and stone, we found, on our examination of this line, to be altogether about thirteen, of which seven are over the railway, and measure from 14 to 20 feet in clear height, and 19 feet in span; the level road-crossings are about thirteen; and field or occupation-crossings thirty-four in number.

GAUGE, RAILS, &c. — The gauge is as the English standard, viz. 4 feet 8½ inches. The rails used on this line consist of three kinds, viz. the old 35 lbs. fish-bellied rail; the parallel rail, which weighs 63 lbs. per lineal yard; and lastly, the bridge-rail, weighing 43 lbs. per yard.

The bearings of the light rails are 3 feet, and of the heavy rails 4 feet, respectively. The joint-chairs used for the 63-lb. rails weigh each 20 lbs.; and the intermediate chairs 16 lbs. The parallel rails are secured with uncompressed keys of pear-tree wood, having a cross section equal to 2 inches \times 2½ inches. The bridge-rails are set on blocks of Bolton grey grit, containing each about 4 cubic feet, and secured thereto by iron spikes, bent down over the lower web of rail, being inserted in wooden plugs, which occupy holes drilled to receive them. The joint-blocks are 27 inches square and 12 inches thick. Some of the bridge-rails are fixed on 1½-inch planks, and these are secured to cross sleepers; but this method is not found to answer very well.

The sleepers are 9 feet in length, 8 inches \times 4 inches, and, together with all timbers used on this line, are kyanized. We observed several of the blocks split; and were informed that many sleepers had been found in a decayed state.

The ballast is of small coal, and is better adapted for this purpose than any other kind of material.

The width occupied by the railway on a level with the surface of the land is 6·66 yards: the cost of which was stated to us at from 150*l.* to 200*l.* an acre.

The fencing consists, for about two-thirds of the line, of posts and two rails, and quick hedge; and for the remainder of stone walling, 4½ feet high, 18 inches thick at the base, and 13 inches at top.

STATIONS AND DEPÔT.—Besides the terminal, there are five intermediate stations, the principal of which are at Leigh and Bag Lane.

The passenger-station at Bolton consists merely of a shed, terminated by a booking-office, which fronts one of the main streets of that town.

At Kenyon, where the railway leaves the Liverpool and Manchester line, there is a lodge and waiting-room, and on the opposite side, at a distance of about 17 feet, a carriage and locomotive engine-shed, which is 42

yards from the siding of the Liverpool and Manchester way. The carriage and engine-house is 101 feet in length by 30 feet in width, and has two lines of way passing through it.

At Bolton there is a spacious dépôt, removed to a convenient distance from the passenger-station. Contiguous to the dépôt are shops for building and repairing wagons, and also the locomotive engine-house. The lathes and other machinery are put in motion by a six-horse engine.

The locomotive establishment at Bolton consists of—

Five smiths, who earn each from	22s. to 26s. per week.
One apprentice „	14s. „
Six strikers „	14s. to 15s. „
Eight fitters „	26s. to 28s. „
Four apprentices „	5s. to 12s. „
Two spring-makers „	22s. and 30s. „
Three turners „	26s. to 30s. „
One screwer „	14s. „
One driller „	14s. „
One planer „	14s. „
Two labourers „	14s. „
Four engine-drivers „	36s. to 40s. „
Four fire-men „	18s. to 21s. „

In the wagons department there are—

Two smiths, who earn each	22s. per week.
One apprentice	12s. „
One shoeing smith	22s. „
Three strikers	12s. and 14s. „
One pattern-maker	22s. „
Two tender-wrights	22s. „
Twelve coach, wagon, and wheelwrights	18s. to 23s. „
Four labourers	14s. „

CARRIAGE DEPARTMENT.—The first-class carriages, which are six in number, will hold each twenty-four passengers in three compartments. The length is 15 feet 3 inches; the inside clear width is 6 feet 6 inches, which allows ample room for four persons of ordinary size. This space is obtained by dispensing with the elbows, which are usually fixed in the first-class carriages of other lines, and add greatly to the comfort of individual passengers.

The inside is lined with blue cloth. The carriage is furnished with spring buffers; and the bodies and wheels are painted green, with the arms of the Company emblazoned on the panels. The weight of each carriage is about 3 tons. The builder is Mr. Cooper, of Bradshawgate, Bolton. The cost of a first-class carriage is 400*l*.

We observed one carriage which holds twenty passengers; viz. sixteen in two regular compartments, and four in a coupé in front.

There are eight second-class carriages, which are each 7 feet wide and 5 feet 3 inches high, close at each end, and open at sides and between the three compartments; some are furnished with common, and some with spring buffers. They will hold twenty-four passengers each.

The turn-tables for carriages are each 10 feet in diameter.

There are about 300 wagons in use on this line, belonging to Mr. Hargreaves, about 40 of which have iron bottoms. Waddington and Crossland's, Galloway and Bowman's, and other wheels, are used on the wagons. They are chiefly of cast iron with wrought tires. The size of a wagon is 10 feet 6 inches long, 7 feet 6 inches wide, and from 6 to 12 inches high; the weight of each being from 35 to 41 cwt. There are fourteen vans, which are 10 feet 6 inches long, 5 feet 7 inches wide, and 5 feet 6 inches high; each weighing about 2 tons.

LOCOMOTIVE DEPARTMENT.—The number and proportions of engines will be seen by an inspection of the Table No. II. in the Appendix.

The tubes used in the locomotives are of iron, brazed; these will last three years.

Three of the engines in use were built by Mr. Hargreaves. These are called the Utilis, the Victoria, and the Castle; two of which are mounted on eight wheels, and therefore present rather a novel appearance. It is stated that the Castle will draw 300 tons on a level at the rate of 15 miles an hour. In July 1839, the Castle took 22 loaded wagons, equal to 110 tons gross, up an incline of 1 in 100 on the North Union Railway, at the rate of eight miles an hour.

Two engines are used constantly for the passenger-traffic; and four are found to answer for the goods-traffic. The goods-engines make three double trips a-day.

The coke used on this line is from Halshaw Moor, about $3\frac{1}{2}$ miles from the place of delivery, and costs 18s. per ton. The coke is measured in baskets, each holding 56 lbs.

STATIONARY ENGINE PLANES.—There are two planes worked by stationary power. These are called the Chequer Bent and Daubhill Inclines. The Chequer Bent ascends at the rate of 1 in 49 and 1 in 30 respectively, for about $1\frac{1}{2}$ miles. It is worked by a fifty-horse condensing engine; the usual pressure of steam being from 7 to $7\frac{1}{2}$ lbs. The rope, made by Webster of Sunderland, is 6 inches in circumference, or, as it is usually called, a six-inch rope; the weight, when new, was about 5 tons, and the cost 50s. per cwt.

The sheeves are of cast iron, some of them being 14 and some 18 inches in diameter, and placed 8 yards apart. We ascended this plane in November last, with a load of 46,944 lbs. in 8·10 minutes, being at the rate of about $9\frac{1}{2}$ miles per hour. The locomotive engine Veteran, which led the train from Kenyon Junction to the bottom of this incline, was also drawn up by the rope.

The Daubhill Incline is worked by a twenty-horse engine in the ascending, and by gravity in the descending direction. The rope from the Chequer Bent Incline, when partially worn, is transferred to work this plane. From the bottom of this incline the train is worked by horse-power to the Bolton station. The signal for starting the stationary engine is given by pulling back the carriages at bottom of the incline, and causing a spanner placed on the rope at top to fall off.

We found the average weight of passenger-trains to be about 25,440 lbs.; and the average speed about $14\frac{1}{2}$ miles an hour.

The average fare for first-class passengers is about $2\frac{1}{2}d.$, and for second-class passengers $1\frac{1}{2}d.$ per mile.

The number of passengers conveyed on this line in 1838 is stated by Mr. Sinclair, the treasurer, to have been 86,320, which is at the rate of about 236 $\frac{1}{2}$ per diem. The receipts for passengers during the same period amounted to 6831*l.* 6*s.* 4*d.*

BRANDLING JUNCTION RAILWAY.

THE county of Durham, to use a provincial phrase, is gridironed with railways. New lines are being added every year to the already large number; and so long as the valuable article coal is found in such vast abundance throughout the various districts of this county, so long will there be capitalists ready to construct these improved ways for the speedy and convenient transport of the produce of the collieries to the places of shipment, and also to land-sale depôts. The railway we are about to describe was projected by Robert William Brandling, Esq., a gentleman of fortune, residing in the neighbourhood of Newcastle. To his enterprising spirit and exertions may be attributed the formation of this way. It is now, however, in the hands of a Company; and Mr. Brandling is the managing director.

The circuitous course followed by this railway will be at once understood when it is stated, that in a direct line from the station at Gateshead to the terminus at South Shields the distance is about $6\frac{1}{2}$ miles, whereas by the railway it is about $8\frac{1}{2}$ miles; and between Gateshead and Monkwearmouth the direct line is $9\frac{1}{2}$ miles, whereas by the railway it is $10\frac{1}{2}$ miles: the distance from South Shields to Monkwearmouth is $6\frac{1}{2}$ miles. The worst curves are of a quarter and half a mile radius.

The main line from Gateshead to South Shields runs for about $5\frac{1}{2}$ miles to Brockley Whins, where the line to Monkwearmouth diverges, and the line from South Shields to Monkwearmouth joins the main line from Gateshead, at a distance from the latter place of about $7\frac{1}{2}$ miles. There is a branch of about a mile in extent from the main line to the Docks at Monkwearmouth; and from Gateshead to Redheugh there is an inclined plane, about 60 chains in length (worked by a stationary engine), which connects the Brandling Junction with the Newcastle and Carlisle Railway. There is also the Boldon Branch, which connects this railway with that of the Stanhope and Tyne.

It is intended to form an inclined plane from the depôt at Gateshead to the Quay on the Tyne, which will be worked by a stationary engine. One drop has been erected at this place; and three drops are already erected at South Shields. The whole length of railway is about $17\frac{1}{2}$ miles.

GAUGE, PERMANENT WAY.—The chief part of this line is laid with a

double way. The gauge is 4 feet 8½ inches; the intermediate space, 5 feet 2 inches; and the side spaces, each 5 feet wide.

The rails are of the parallel form (see Plate III. fig. 8), similar in every respect to the last rail introduced on the Newcastle and Carlisle Railway, and fixed in chairs, at distances from middle to middle of 3 feet. On the embankments the chairs are fixed to larch sleepers, 8 feet long, and 8 inches by 4 inches in substance. The blocks, which are placed diagonally, are of freestone, from Whitehouse Quarry, and contain each about 4 cubic feet; the ballasting is chiefly of broken stone.

EARTHWORKS, &c.—There are some heavy earthworks, particularly on the main line from Gateshead to Monkwearmouth. One embankment in particular may be mentioned as having, from the slippery nature of the clay, caused considerable expense in preserving the levels for the rails.

In consequence of opening this portion of the line at too early a period, the travelling over it was of the most extraordinary description we have experienced on any railway in the kingdom; for, besides the snail's pace at which the train proceeded, the motion of the carriages was precisely similar to that of a boat in a somewhat troubled sea.

It is an error, which most railway Companies have fallen into, to open their lines, or portions, before the embankments have sufficiently subsided to allow, if not of a safe, at any rate of an easy passage for the heavy trains made to pass over them. Some of the consequences of such hasty proceedings are to entail a large additional outlay on the proprietors, to bring discredit on the particular railway, and to give the now happily few enemies to the railway-system just cause for complaint. The Great Western Railway would never have had half the enemies arrayed against it, but for the imperfect state of the way at the time of opening.

In some of the cuttings retaining walls are used to a considerable extent; the slopes of the cuttings and embankments are generally grassed over.

The open drains are paved at bottom, and appear to be of full section to carry off the water. The fencing consists of stone walling, and also of posts with three rails; but a great deal of the wooden fencing has only two rails.

BRIDGES AND LEVEL CROSSINGS.—In our view of this line we counted about thirty bridges under and over, fourteen level road-crossings, and two level

field-crossings, besides one rope-way. The bridges are in general neatly, and apparently solidly constructed, of stone and brick. The chief bridge in point of design carries the railway over a main street at Gateshead; it consists of three openings — one for the carriage, and two for the footways. The girders and entablatures are supported on plain Doric columns; and the whole is well suited to its particular locality. The greatest error, however, committed in laying out this work is the crossing on a level the Stanhope and Tyne Railway, a coal-line in full work, which is performed chiefly by powerful locomotive engines. How frightful the idea of a collision of two powerful engines travelling at considerable velocities, which frequently may occur without the most judicious arrangement of signals! In fact, a collision actually did take place at the time we were last at Newcastle; but the particulars we were unable to learn. Too much cannot be urged against this fatal error, which involves the safety of so large a class of people daily; and it is to be hoped that, for the expense of a few thousands, the possibility of such alarming consequences will not be allowed to continue.

STATIONS AND DEPÔTS. — The station and depôt at Gateshead are contiguous to each other, and occupy together a large area.

We are far from being pleased with the arrangement of the passenger-station, which may be thus described. In front of the offices there is a square open space, which is considerably elevated on arches, and approached from one of the main streets at Gateshead by an inclined carriage-way. At the north-west corner of this open space or court-yard is erected a sort of tower, which encloses a spacious staircase intended for those who arrive on foot; but instead of this staircase leading at once to the offices under cover, the passengers, be the weather what it may, have to walk across the court-yard to reach the booking-office. Besides the booking-office and general waiting-room, which are in one, there is a small room set apart for ladies.

In the rear, and parallel to this building, is the passenger-shed, which is an erection of ordinary construction. The brickwork of this station, although to appearance solid, is of rough exterior.

The stations at Monkwearmouth and South Shields are more conveniently arranged; but are of common construction. The two intermediate stopping-places, at the time of our examination, were not furnished with proper offices.

INCLINED PLANE TO REDHEUGH. — That portion of the line which runs from Gateshead to Redheugh is worked entirely by a stationary engine. The length from the Gateshead depôt to the junction with the Newcastle and Carlisle Railway, is about 60 chains. It is partly in cutting and partly on embankment, and has a double way throughout.

The sheeves are of cast iron, 24 feet from centre to centre, $18\frac{1}{2}$ inches diameter, and $5\frac{1}{2}$ inches wide, set in wooden cases, 20 inches long, $6\frac{1}{2}$ inches wide, and 10 inches deep.

In the curves the sheeves are sufficiently inclined to the horizon. This Incline is furnished with a 6-inch rope, which weighed when new 2236 lbs., and is stated to have cost 150*l*. It works round a horizontal wheel at the bottom of the incline in the usual manner.

The engine-house is 42 feet long, and 16 feet wide in the clear. There are three boilers, each 30 feet in length, and 7 feet diameter. The engine is called a 60-horse; it has a cylinder 31 inches in diameter; stroke, 6 feet; working beam, 21 feet long; fly-wheel, 21 feet diameter; rope-roll, 12 feet diameter. The usual load, which consists of four wagons filled with coal, is equal to 43,456 lbs. gross. The time occupied in the ascent is usually about $2\frac{1}{2}$ minutes. The quantity of coals drawn up daily amounts to about 18 keels, each weighing 22 tons, or total weight 396 tons. Small coal is the fuel usually burnt for this engine. The signals for starting the engine, &c. between the top and bottom of incline, are passed by a boy stationed in an elevated position on the side of the way.

CARRIAGE DEPARTMENT.—The first-class carriages, four in number, are in three compartments; and are intended to hold each twenty-four passengers. They are mounted on Losh's wheels, 3 feet in diameter, have only single buffing apparatus, and are furnished with a footboard on each side.

The second-class bodies, which are 14 feet 7 inches long, and 6 feet 2 inches wide, have also three compartments each, calculated to hold ten passengers. A footboard of wood, lined with plate-iron, runs along the whole length of the carriage on each side, and is of great convenience to the guards, who may thus safely walk along the side of the whole train when in motion. There are altogether eighteen second-class carriages. Losh's wheels are used for all the passenger-carriages of this railway, which are from the coach-works

of Mr. Atkinson, of Newcastle. The carriages are painted a bright yellow, and picked out with black.

There are nine goods-trucks, mounted each on Hawke's wheels.

There are upwards of 400 wagons at work on this line, built chiefly by Mr. Burnup, of Newcastle; but we were informed that the required number would be about 1500. The net weight of each wagon is about 44 cwt., and of size sufficient for 53 cwt. of coal. The wheels are of cast iron, 3 feet in diameter, and were generally furnished by Messrs. Hawkes and Co., of Gateshead. The cost of keeping a wagon in repair is estimated in this county at about 4*l.* per annum. The wagons are coated with tar—a practice which it would be very advisable for other railway companies to adopt.

LOCOMOTIVE DEPARTMENT.—The engines used on this line have all six wheels: their proportions will be found by reference to Table No. III. of the British Locomotives, in the Appendix.

The tenders have each four wheels, 3 feet 6 inches in diameter; and are calculated each to hold 800 gallons of water, and a ton of coke.

The coke used on this line is partly from Mr. Summers' ovens, Sunderland Moor, and partly from one of Lord Ravensworth's collieries to the south of the Redheugh branch of the Newcastle and Carlisle Railway.

The result of five trips on the different locomotive portions of this line gave an average speed of about 15 miles per hour, the average load being about 30 tons.

The whole of the works have been executed under the direction of Mr. Nicholas Wood. The main line from South Shields to Monkwearmouth was opened to the public on the 18th of June, 1839, and from Gateshead to South Shields, and also to Monkwearmouth, in the following September.

The fare for a first-class passenger from Gateshead to Monkwearmouth is 1*s.* 6*d.*; and for a second-class passenger, 1*s.* From Gateshead to South Shields the first-class fare is 1*s.*, and the second-class fare 6*d.*; and from South Shields to Monkwearmouth the first-class fare is 1*s.*, and the second-class fare 9*d.* The trains run daily seven times in each direction, except on Sundays, when there are five trains each way. The first-class carriages are not very much in request.

The following exhibits, somewhat more in detail than usual, the items

of expenditure in the construction and furnishing of this line, to 30th June, 1839—

Purchase of some property	£61,222	8	7	
Earthworks	57,410	8	7	
Masonry	46,194	12	10	
Rails, chairs, and keys	35,749	2	6	
Laying permanent way	7,442	16	3	
Working materials	4,932	6	3	
Stone blocks	4,383	11	9	
Labour	3,281	0	2	
Larch sleepers	2,417	19	9	
Wooden fencing	1,920	11	10	
Timber	1,170	9	4	
Bricks	790	0	0	
Patent felt	349	16	0	
Wooden bridges	255	7	7	
Oak pins	235	8	5	
Contracts not completed	2,785	18	1	
Compensations	6,914	8	8	
				237,456 6 7
Law charges	6,363	14	2	
Interest	4,792	19	0	
Salaries	4,643	11	4	
Incidental expenses	1,580	6	4	
Surveying	1,359	6	7	
Printing and advertisements	487	15	11	
Direction	36	15	0	
Rents for the line	950	17	1	
Interest under the Blaydon and Hebburn Act	9,000	0	0	
Coke	29	10	0	
Petty cash	40	14	0	
				29,285 9 5
Locomotive engines	7,248	15	0	
Engine-house	74	5	3	
Water-tanks	14	7	0	
Stationary engine	1,790	0	0	
Passenger-carriages	1,210	0	0	
Goods-trucks	528	0	0	
				10,865 7 3
				277,607 3 3
Due to sundries	49,363	13	7	
Total cost to 30th June, 1839	£326,970	16	10	

In four months, ending 31st January, 1840, the number of passengers conveyed on this line amounted to 186,486, or at the rate of about 1218 per diem; the receipts for the same period being on an average 46*l.* 11*s.* 5½*d.* a-day. The proportion of second to first-class passengers was as 7·66 to 1.

CANTERBURY AND WHITSTABLE RAILWAY.

THE Canterbury and Whitstable was the first railway in the south of England worked by stationary and locomotive engines. It was projected by Mr. William James, who also originally proposed the Liverpool and Manchester Railway; but who, like many others, spending his time and means for the public good, died a poor and neglected man.

The first Act of Parliament for the construction of this railway was passed in 1825, being the 6th of Geo. IV. chap. cxx. Three additional acts have subsequently been obtained; the first received the royal assent on the 2d April, 1827, by which the Company were empowered to raise an additional capital in joint stock of 19,000*l.* By the second, which received the royal assent on the 9th May, 1828, 21,000*l.* additional; and by the third, dated 21st July, 1835, a further sum, by loan, of 40,000*l.*

It was opened to the public on the 3d May, 1830; and although it is of great use to the citizens of Canterbury, and the district generally through which it passes, it is far from having answered the proprietors' expectations.

When we visited this line in 1831, it was partly worked by fixed engines, partly by one locomotive engine, and partly by horses; but in 1839 we found that the locomotive engine had been dispensed with.

The course of this line is nearly direct between the station at Canterbury and the harbour at Whitstable. It is divided into five planes; the first of which rises from Canterbury for 3300 yards, at the rate of 1 in 46, to the engine-station at Tyler's Hill. The next plane is also on an ascent, rising at the rate of 1 in 750, for 1980 yards to the second engine-station at Clow's Wood, which is the summit of the line. The line thence descends for a length of 1760 yards, at the rate of 1 in 31. For the next 2200 yards, the

line is nearly level. Of the two remaining planes to Whitstable, the first descends at the rate of 1 in 53 for 880 yards; and the second is nearly level, being 440 yards in length. Thus the whole length is six miles.

The principal traffic is in coals, which are brought coastwise to Whitstable, and thence by the railway to Canterbury. Passengers are also conveyed at a moderate rate of charge; but the receipts on this account are not considerable.

The fixed engines at Tyler's Hill and Clow's Wood are two of 25-horse and one of 15-horse power each, respectively. The ropes used are of $3\frac{1}{4}$ inches circumference. The sheeves are of 10 inches diameter, and 8 yards apart.

The way is single throughout; the gauge is 4 feet $8\frac{1}{2}$ inches, and each side-space 2 feet $7\frac{1}{2}$ inches wide; the top width of embankments being 10 feet. The rails are of wrought iron, of light weight, and are set in chairs with 3 feet bearings; the chairs being spiked down to cross sleepers of oak.

The line is at present on lease to Messrs. Nicholson and Bayliss.

CHESTER AND BIRKENHEAD RAILWAY.

THERE is a neck of land running between the river Dee and the river Mersey, and bounded on the north by the Irish Sea, which is about thirteen miles and a half in length, and six miles in breadth. About five miles south of its base is the ancient city of Chester; and on the eastern side is the thriving town of Birkenhead, situate on the Mersey, and immediately opposite to Liverpool. Between the two former places the Chester and Birkenhead line is carried, being an extension of the Chester and Crewe Railway.

So much was thought of these railways extending from the Grand Junction Railway at Crewe to Birkenhead, as a shorter and better line to Liverpool than by the present route, that there was another line in Parliament, in the session of 1837, to effect the same object: this was intended to have been called the Chester Junction Railway. We shall not stop to consider whether the abandoned line was better than those now carried into execution, but at

once proceed with an account of the Chester and Birkenhead Railway, which is really in existence.

The first act obtained for the construction of this railway received the royal assent on the 12th July, 1837, which authorised the Company to raise a capital in joint stock of 250,000*l.* and an additional sum by loan of 80,333*l.* A second act was obtained during the late session, which received the royal assent on March 23d, and gave power to this Company to raise an additional sum of 166,666*l.*, making altogether the sum of 496,999*l.*

COURSE OF LINE AND INCLINATIONS.—The general course of this line is nearly south and north. Leaving Chester at Brook Street, it passes by Moston, Capenhurst, Sutton, Hooton, Greenfield, Bromborough, and Howey Lane, to its termination at Birkenhead. The quickest curves are of a mile radius. Commencing at Chester, the following is the order, length, and inclination of each plane:—

Lengths of Planes.		Ratio of Inclination.		Locations.
Miles.	Chains.			
1	15	ascending at the rate of 1 in 1650		to Upton.
1	10	ascending „ 1 in 660		to Moston.
2	40	ascending „ 1 in 330		to Capenhurst.
1	00	level.		
	70	descending „ 1 in 440		to Sutton.
1	25	descending „ 1 in 550		to Hooton.
1	35	level.		
1	19	descending „ 1 in 440		to Bromborough.
1	50	descending „ 1 in 600		to Howey Lane.
1	70	descending „ 1 in 508		to Holt Hill Road.
	16	descending „ 1 in 330		
	30	descending „ 1 in 100		to Birkenhead.
14	60			

The branch to the Woodside Ferry is 30 chains in length, and descends at the rate of 1 in 511. Thus the whole distance from the Chester station to Woodside Ferry is 15 miles 10 chains. With the exception of one plane, which inclines at the rate of 1 in 100, the gradients all come within the first class.

EARTHWORKS, &c.—The total amount of cuttings is 1,200,500 cubic yards. The largest cutting is at Derby House, about three miles from Birkenhead, amounting to 240,000 cubic yards; and the largest embankment that at Moston, containing 365,000 cubic yards, being composed of clay and sand. The slopes are $1\frac{1}{2}$ to 1, where the height is under 35 feet; and 2 to 1 where above that height. The slopes are soiled, and sown with grass-seed.

The line was originally divided into four contracts; viz. the Bebbington contract, containing 253,000 cubic yards of earthworks, and 8527 cubic yards of brickwork and masonry, in bridges, culverts, &c., and extending for a distance of 2 miles 32 chains; the Bromborough and Eastham contract, containing 288,000 cubic yards of earthworks, and 15,000 cubic yards of masonry and brickwork, its length being 3 miles 37 chains; the Sutton contract, 3 miles 17 chains in length, and containing 209,500 cubic yards of earthworks, of which 29,000 are deposited in spoil banks, and 4339 yards of masonry and brickwork; and, lastly, the Moston and Chester contract, containing 450,000 cubic yards of earthworks, and 13,500 cubic yards of masonry and brickwork, the longest lead being about two miles, and the average lead a mile. Thus the whole quantity of earthworks in these four contracts amounted to 1,200,500 cubic yards, or at the rate of about 82,451 yards per mile; and 41,366 cubic yards of brickwork and masonry, or at the rate of about 2841 yards per mile.

The Moston and Chester contract not being proceeded with by the contractors in a satisfactory manner, the Company were obliged to take it into their own hands, finding wagons, rails, and other necessities, and letting the works to be executed by several sub-contractors.

In April 1839 there were 1117 men employed on the works, and 98 horses; or at the rate of nearly seventy-seven men and seven horses per mile.

The original contracts were let with the condition that the contractors should find all labour, tools, implements, and materials, except rails, chairs, and fastenings.

BRIDGES, &c.—There is one tunnel in the Woodside Ferry branch, which is 573 yards in length, and 16 feet high. The bridges over the railway are 30 feet wide, 16 feet clear height in centre, and having generally arches of segmental form, rising 7 feet 6 inches; the arches and parapets are of brick, and the abutments, piers, and dressings, are of stone.

The viaduct at Moston, carrying the railway over the Ellesmere Canal, is the principal work of the kind; it has eleven arches, and is 41 feet in height above the surface of the water. The piers are of red sandstone, and the arches of brick. The centre arch, which is built at an angle of 45° , is of 50 feet span; and the side arches each of 20 feet, and two bricks in thickness. Viewed from the canal below, this structure has an imposing effect.

GAUGE OF WAY, &c. — The whole width of land enclosed on a level is 48 feet; the width of cuttings and embankments on level of rails is 30 feet; the gauge of way is 4 feet 9 inches; the intermediate space is 6 feet 5 inches; and each side space is 7 feet $\frac{1}{2}$ inch. The rails are of the single parallel form (see Plate III. figs. 9 and 9 a), weighing 56 lbs. to the yard; they are set in chairs, and secured thereto by a ball and key, as the Manchester and Leeds rails; the intermediate chairs measure each 10 inches by 5 inches, and weigh 21 lbs. each; and the joint-chairs, 11 inches by $5\frac{1}{2}$ inches, weighing 24 lbs. each; the chairs are secured to cross sleepers, with $\frac{3}{4}$ -inch spikes 7 inches long; the sleepers are of larch and Scotch fir, some of which are kyanized, about two-thirds of the line being laid with sleepers; the larch sleepers are 9 feet in length, and measure 10 inches by 5 inches; and the fir sleepers for the joint-chairs are 11 inches by $5\frac{1}{2}$ inches, being half logs, and for intermediate chairs, 10 inches by 5 inches.

The ballasting is of broken red sandstone, occasionally mixed with sand, its depth below sleepers being one foot; the fencing consists chiefly of posts and three rails, the posts being 10 feet apart.

CARRIAGES AND ENGINES.—The carriages consist of first and second class, agreeing in design and arrangement with those of the Grand Junction Railway. Four of the locomotive engines are from the works of Messrs. Mather, Dixon, and Co., of Liverpool; they have 12-inch cylinders; 18-inch stroke; two driving-wheels, 5 feet 6 inches diameter; and four bearing-wheels, each 3 feet 6 inches diameter; 130 tubes of $1\frac{1}{2}$ inches diameter, and 8.50 feet in length; the fire-boxes are 32 inches long, 40 inches wide, and 40 inches high; the boilers are 40 inches in diameter, and 8 feet in length; the area exposed to radiating caloric is 43.98 square feet, and to communicative heat 468.52 feet; together equal to 512.50 square feet.

The preliminary expenses of surveys and sections, obtaining the Act of Parliament, and staking out the line, &c., include the following items:—

Engineering and surveying	£5818 14 1
Parliamentary and law expenses	9132 16 4
Deputation and travelling expenses, and direction	1466 1 0

The whole of the works have been executed under the immediate direction of Mr. John Dixon, formerly of the Liverpool and Manchester Railway, Mr. Stephenson being consulting engineer.

CHESTER AND CREWE RAILWAY.

THE ancient city of Chester will, no doubt, ere long become one of the principal railway-stations in the kingdom; already it is in railway connexion with the metropolis, with Birmingham, with Liverpool and Manchester, and many other important towns: this extensive communication is completed by the Chester and Crewe line, which diverges from the Grand Junction Railway at Crewe, and has lately become part and parcel of the Grand Junction Company's property. Foreseeing that much of the Liverpool traffic was likely to be abstracted from the Grand Junction Railway, that Company wisely secured it by purchasing this valuable adjunct.

The first Act of Parliament for the construction of this line received the royal assent on the 30th June, 1837. The Company had power thereby to raise a capital in joint stock of 250,000*l.*, and in addition 83,333*l.* by loan, making together 333,333*l.* By the Chester and Crewe Consolidation Act, passed in the late session, and which received the royal assent on the 19th of May, 125,000*l.* additional was authorised to be raised for the purposes of the Act. The arrangement made between the Grand Junction Company and the late proprietors of the Crewe line is, that for every 50*l.* share held by the latter in the Crewe line, they shall become 25*l.* shareholders in the Grand Junction Railway.

COURSE OF RAILWAY. — Leaving the Grand Junction line a little to the north of the Crewe station, with a curve of eighteen chains radius, the line is traced close to Oak Farm and Coppenhall Hey, from whence it is produced in a direct line close to Aston Hall, crossing in this length the river Weaver; from Aston Hall, the line, slightly curving, crosses the Middlewich and Wardle Canal, near Cholmondestone Lock; from whence, in a recurving course, it nears Wardle Bank, and thence passing near to, and on the north of, the Chester Canal, crosses it near Bunbury Locks; thence, keeping nearly parallel and close to the Canal, continues in a curvilinear course and on the north side of Beeston Castle, and intersecting Tattenhall and Newton townships, again approaches the Canal near Bebbington's Bridge; from whence, in a straight direction, it continues to Saighton Lane, and passing on the south side of Newton, again crosses the Canal about a third of a mile to the west of Christleton Bridge; and thence passing through Great Boughton township, terminates at Brook Street, Chester, where its junction with the Chester and Birkenhead Railway is effected.

With the exception of about five miles, the whole line is made up of a series of curves. The curve at Crewe is, however, the only objectionable one throughout.

INCLINATIONS. — This railway is laid out with first-class gradients; there are altogether nine planes, with gradients varying from 13·20 to 1·25 feet; the whole of which are on a descent towards Chester, except the third plane from Crewe, which is two miles in length, and has an 11-feet gradient.

EARTHWORKS, BRIDGES, &c. — The earthworks, according to Mr. Gladstone, the resident engineer, have cost about 11*d.* per cubic yard, the longest lead being two miles, and the average lead about three quarters of a mile. The principal contracts were the Bunbury, Wardle, Waverton, and Crewe. In the Waverton contract, which included 317,000 cubic yards of earthworks, the progress made was at the rate of 26,250 yards a-month. The width of cuttings and embankments is 30 feet; the whole width of land on a level is 48 feet. The principal bridge-work is the viaduct over the river Weaver, which consists of eight arches, each of 40-feet span, the versed sine being 18 feet; the piers are each 6 feet in thickness, and the width

between parapets is 28 feet; the height from the ordinary level of the Weaver to the surface of the rails is 60 feet.

The aqueduct taking the Ellesmere Canal over the railway is the next work of this kind in point of magnitude; it is 405 feet in length, and consists of two segmental arches, each of 15 feet span, and rising 5 feet; the arches are two bricks in thickness; the abutments, 4 feet 6 inches; and the pier, 3 feet 4 inches; the invert is 14 inches thick; and the versed sine of each respectively is 3 feet. The whole is constructed of brickwork, with several courses of footings; the bottom of which range with the lowest points of the inverts.

GAUGE OF WAY, RAILS, &c. — The gauge of way is 4 feet 8½ inches; the rails are in 15-foot lengths, and of the single parallel form, weighing 56 lbs. to the yard: they are fixed in intermediate and joint-chairs; the former weighing 20 lbs. each, and the latter 24 lbs. Both stone blocks and sleepers are used; the blocks are from Congleton, and contain each 4 cubic feet; the sleepers are of larch and Scotch fir, of which there are 40,000 of the former, and 20,000 of the latter; felt is used where the chairs rest on blocks; each chair is laid with an inclination to the horizon of about ⅜ths of an inch in its length. The ballasting consists of sand and broken stone; under sleepers the sand is 14 inches in thickness; and under blocks, 7 inches; in each case there is a super-layer of broken stone, 4 inches in thickness. Under the Ellesmere Canal aqueduct the rails are laid on longitudinal timbers, 12 inches by 6 inches. The fencing consists of posts and three rails, the distance from middle to middle of posts being 9 feet. Where the cuttings are through sand, the side-drains are covered over.

CARRIAGES. — The carriages consist of first and second class, corresponding in size and weight with those of the Liverpool and Manchester Railway; they are furnished with Losh's wheels: the first-class carriages hold, as usual, each eighteen, and the second-class twenty-four passengers.

THE CLARENCE RAILWAY.

THE railways in the county of Durham, which are by far more numerous than in any other county of England, are chiefly for the transport of coals, although on most of these lines passenger-carriages are introduced; and, in some instances, as in the case of the Stockton and Darlington, the traffic in passengers is considerable.

The Clarence Railway Company have obtained not fewer than six Acts of Parliament, authorising them to raise altogether 500,000*l.*;* of this amount, 60,000*l.* is by loan, and the remainder in joint-stock.

COURSE OF RAILWAY.—The general direction of the main line is from east to west. It commences at Port Clarence, on the north side of the river Tees, near Haverton Hill, and opposite to Middlesborough, the eastern terminus of the Stockton and Darlington Railway; from Haverton Hill the line is traced through the townships of Norton, Carlton, Whitton, Stillington, Elstob, Preston-le-Skerne, Woodham, and Great Aycliffe, and terminates by a junction with the Stockton and Darlington Railway at Sim Pasture, in the parish of Heighington; the whole length of the main line being 14 miles 2½ chains.

Besides the main line, there are three branches: first, the city of Durham Branch; second, the Byer's Green Branch; and third, the Stockton Branch.

* The first Act received the royal assent on the 23d May, 1828, and authorised the Company to raise in joint stock		£100,000
And by loan		60,000
The second Act is dated 1st June, 1829, and empowered the Company to raise additional		100,000
The third Act, dated 3d April, 1832		100,000
The fourth Act, dated 29th March, 1833		60,000
The fifth Act, dated 18th June, 1833		20,000
The sixth Act, dated 12th July, 1837		60,000
		<hr/>
		£500,000
		<hr/>

The City of Durham Branch leaves the main line close to Stillington Moor House, and runs in nearly a north-western direction for more than half its length, the remainder of the line being carried in a course bearing rather to the east of north, and terminates near Crow Trees, in the township of Quarrington : the length of this branch being 10 miles 13 chains.

The Byer's Green Branch diverges from the City of Durham Branch in the township of Ferryhill, and pursues a direction a little to the south of west, terminating in the township of Byer's Green : the length being 5 miles 72 chains.

The Stockton Branch runs in a direct course from the main line by the Norton toll-gate, in the township of Norton, to the river Tees, crossing the Stockton and Sunderland turnpike-road on a level, about a quarter of a mile north of the town of Stockton : the length of this branch is 2 miles 30 chains.

Thus the whole length of railway belonging to this Company, and chiefly laid with two sets of rails, amounts to 32 miles 37 chains.

There are numerous curves in the main line, and City of Durham and Byer's Green Branches; but these are of less consequence for coal-trains travelling at low rates of speed. In those parts of the line and branches travelled over by the passenger-trains, the worst curve is at the divergence of the Stockton Branch from the main line, which is of about a quarter of a mile radius.

GENERAL INCLINATIONS.—The main line from the eastern terminus at Port Clarence to the Stockton and Darlington Railway at Sim Pasture, rises on an average at the rate of about 1 in 270. The City of Durham Branch rises from the main line to its termination at Quarrington at an average rate of about 1 in 450. The Byer's Green Branch rises from the main line for a distance of 2 miles 75 chains at an average rate of about 1 in 130, the remainder being level; and the Stockton Branch falls from the main line to the river Tees on an average at the rate of 1 in 209.

EARTHWORKS, BRIDGES, &c.—The earthworks are generally heavy throughout. The principal works in this department on the main line are the Bilingham Beck embankment, the Norton toll-gate cutting, the Bishopton Beck embankment, the contiguous cutting westward, and the Stillington Moorhouse

embankment. On the City of Durham Branch, the Rudshill cutting in limestone, being nearly 70 feet in depth, and the cutting at Quarrington, appear to be the heaviest works. In the slopes of cuttings, some of which are in a very slippery state, troughs of stone are introduced to take the water from the upper into the lower drains.

On $16\frac{1}{4}$ miles of the line, on which parts alone passengers are carried, commencing at Stockton and ending at Coxhoe, we counted eleven bridges over the railway, nineteen bridges under, six level road-crossings, and thirty-eight level field or occupation-crossings; the bridges are generally of brick, with stone imposts, parapets, and dressings.

GAUGE OF WAY, RAILS, &c. — The gauge of way is 4 feet $8\frac{1}{2}$ inches; the rails are of the parallel form (see Plate III. fig. 10), weighing 44 to 45 lbs. to the yard; but the old rails weigh only 38 lbs. to the yard; the rails are set in chairs in the ordinary way, the chairs being secured to cross sleepers or stone blocks with wooden pins: the stone blocks are, however, in parts being removed, and cross sleepers substituted. The ballasting is of small coal; the fencing consists of posts and three rails, and in parts of stone walling. The mile-standards, where the line is on embankments, are inconveniently placed at the bottom of the slopes.

The permanent double way is kept in order by contract, at about 100*l.* per mile per annum, the contractors finding oaken pins. The Company employ three inspectors to see that the work is properly attended to. The number of waymen is stated to be three per mile.

TRAINS, CARRIAGES, &c. — The Company have leased the carriage of passengers to Mr. Walton, of Norton, who pays the greatest possible attention to the accommodation and convenience of the public. Mr. Walton finds his own engines and carriages; and with regard to the latter, they are but little inferior to those belonging to passenger-railways generally.

The usual train consists of one mixed and one second-class carriage; the mixed carriage has a first-class compartment in the middle; and a second-class compartment at either end; each compartment holds eight persons. Mr. Walton states, that the mixed carriage cost only 145*l.*, and that it had run 28,000 miles without any repair. The second-class carriage is in three

compartments, and will hold thirty persons; the cost is stated to have been 142*l*. The train runs three times daily in each direction, being a distance of 16½ miles, between Stockton and Coxhoe, which is about 4½ miles to the south-east of the city of Durham. The charge for first-class passengers is at the rate of 1·84*d*. per mile; and for second-class passengers, 1·47*d*. per mile. The trains, contrary to established custom on other railways, run on the right instead of the left way. The passenger-trains started regularly with locomotive engines in June 1838. In 1836, the passenger-coach was drawn by one horse. In ten months, from July 1838 to April 1839, both inclusive, the number of passengers conveyed on this line amounted to 16,197, or about on an average 60 per working-day: the amount received for that period being 1556*l*. 18*s*. 9*d*. The greatest number was conveyed in the month of August.

MR. NORTON'S ENGINES.—In the autumn of 1839, Mr. Norton had two engines at work, the Victoria and the Norton. The Victoria has 13-inch cylinders and 18-inch stroke; one large fire-tube and 75 small tubes, each 1½ inches diameter, and four coupled wheels 4 feet 6 inches diameter. The usual working pressure is 55 lbs. This engine was built by Mr. Lister, of Darlington, and cost 750*l*.; the repairs Mr. Norton found to amount to 500*l*. in about fifteen months. Coal from Thristlington is used with this engine, the cost being 20*s*. per Newcastle chaldron.

The Norton was built by Messrs. R. and W. Hawthorn, and has 14-inch cylinders and 15-inch stroke, 135 tubes, and four wheels, each of 4½ feet diameter. The tubes were reinstated once in the three years this engine had been at work. The coke consumed by the Norton, leading the two passenger-carriages on a double trip of about 32½ miles, costs 2*s*. The ordinary pressure of steam is about 40 lbs.

We found the average speed of the trains, exclusive of stoppages, to be about 18 miles an hour; the average weight of the trains being about 16,188 lbs. The stoppages average each about 1½ minutes.

THE COAL-ENGINES.—In the autumn of 1839, the number of coal-engines belonging to this Company was twelve; and two had been lately ordered of T. Hackworth, of Shildon. Their speed is limited to eight miles an hour;

and the usual working pressure is 45 lbs. The ordinary loads for six-wheeled engines are thirty-two empty wagons ascending from the Tees, or the same number laden descending from the collieries; or with four-wheeled engines twenty-four wagons. The thirty-two wagons weigh net 51 tons 4 cwt., and gross 136 tons.

The engines are generally similar to those which have been so long in use on the Stockton and Darlington Railway, with outside cylinders, six coupled wheels of 4 feet diameter, and single return tubes; the whole length of engine being about 16 feet, the gross weight about 12 tons, and the cost about 900*l.*, including 40*l.* for wooden tender with water-butt. The butts hold from 500 to 600 gallons.

The Company pay the engine-drivers $\frac{1}{4}$ ths of a penny per ton per mile for all coals conveyed on the railway, the driver providing a fireman, and finding coals, fire-bars, oil, lamps, &c.; and the Company keeping the engines in repair. The coal costs about 17*s.* a Newcastle chaldron, or 6*4*1*s.* per ton. The wagons belong to the coal-owners.

The quantity of coal conveyed on this line amounts to about 400,000 tons annually. There are four drops at Port Clarence, by which eighty-one keels can be shipped in twelve hours.

DUBLIN AND KINGSTOWN RAILWAY.

THE introduction of a simple and economical system of railways into the sister kingdom would, no doubt, be attended with considerable national advantage. Abundantly favoured by nature, and assisted by art to an amazing extent already, we must ever look upon Ireland as a neglected country, until we see its peasantry on a footing with the labouring classes of Great Britain. No plan that could be devised would, we are inclined to believe, so soon amend this defective state of things as that to which we have alluded above.

Although several Acts of Parliament have passed for the construction of

railways in Ireland by joint-stock companies, two only at present are in active operation—the Dublin and Kingstown, and part of the Ulster Railway. The first act for the construction of the Dublin and Kingstown Railway received the royal assent on the 6th September, 1831; by which the Company were empowered to raise a capital in joint stock of 200,000*l.*, and to borrow an additional sum of 70,000*l.* Up to 1st March, 1838, the total expenditure in the construction of the works was 303,724*l.* 17*s.* 1*d.*

COURSE OF RAILWAY.—This line commences at the station in Westland Row, Dublin, which is about 54 chains from the Post-office in Sackville Street. From this station the line takes a curvilinear course between Great Brunswick Street and Grand Canal Street, crosses the Dock about 150 yards from the entrance to the Canal, thence passes on the left of Beggar's Bush Road, and leaving the Botanic Gardens about 200 yards on the right, crosses the river Dodder, and proceeds in a direct line to Merrion, beyond which it is carried by an embankment across Dublin Bay to Black Rock, a distance of about 1½ miles. From this place to its termination at Kingstown the line is entirely curved; alternately crossing the strand, and passing through limestone cuttings, it is produced to the left of Monkstown and Dunleary, thence crossing the old Harbour, terminates near the south-west angle of the Royal Harbour at Kingstown.

INCLINATIONS.—Commencing at the Dublin station, the line descends to the north side of the Grand Canal Dock at the rate of 1 in 440, and passes over the Dock by a short level plane. Thence to circular road the ratio of inclination is 1 in 440, still descending. The fourth plane descends at the rate of 1 in 528 to near Haigh's Lane. The fifth, also descending at the rate of 1 in 440, extends to a point just beyond Sandymount Lane; from which the line is level to within ten chains of Salt Hill. The next plane ascends at the rate of 1 in 440, to the north side of Dunleary Old Harbour; from whence to the Kingstown terminus the last plane ascends at the rate of 1 in 730. The whole length is about 6 miles and 100 yards, or more than half a mile shorter than by the old road.

CURVES. — Nearly the whole line is in a slightly curving course; but

excepting two portions towards the Kingstown end, which are in curves of about half a mile radius, the curvature is easy throughout.

EARTHWORKS, &c. — From Westland Row to the Serpentine Avenue, a distance of 1 mile and 30 chains, the railway is carried by an embankment about 20 feet high on an average, and supported on either side by retaining walls, averaging about five feet in thickness, and built to a batter of 1 in 20. From the Serpentine Avenue to Merrion, the earthworks are but slight; but beyond Merrion the railway is carried by a sea-embankment, which extends uninterruptedly to Blackrock. This embankment is about 50 feet wide on a level with the rails, and about 95 feet at the base; the height being about 12 feet. It is chiefly formed from side-cuttings in the sand contiguous to the work, the whole being covered with a mass of earth, gravel, and rubbish, taken from the shore. The face of the embankment is paved throughout with stones of from one to twelve cubic feet each, the whole being laid with a slope of three to one. The foundation is carried down about two feet below the level of the sand; and the parapet, which is 2 feet 3 inches thick on the top, and two feet thick at one foot from the top, is finished as to its face in the form of a parabolic curve, the object of which is to prevent the sea from washing over the railway. This parapet is 3 feet 6 inches in height. There is a cutting opposite to Blackrock House, the depth of which is about 36 feet, and the length about seven chains, the slopes being formed at half to one. The railway is again carried over the strand by a similar embankment to that already described. The next cutting is at Seapoint Field, and is 23 feet in depth on an average, and a quarter of a mile in length. Through Salt Hill is another cutting, about 32 feet in depth, 48 feet wide at level of rails, and 10 chains in length.

BRIDGES, &c. — There is one short tunnel, of 90 feet in length, contiguous to the Blackrock cutting, which is 30 feet wide and 24 feet high, the arch being semicircular.

The principal bridges are over Cumberland Street, Great Clarence Street, the Grand Canal Dock, Irishtown Road, and the river Dodder. The arches are generally semi-elliptical, the span of each agreeing with the width of roads crossed. The bridge over the Grand Canal has three arches, each of 30 feet

span, and having a versed sine of 8 feet; and that over the river Dodder has three small arches, each of 21 feet 8 inches span, the versed sine being 4 feet. Most of these bridges are built with skew arches; the most acute angle being that of the Irishtown Bridge, which is $33^{\circ} 45'$. The bridges over the railway are of 30 feet span, and 20 feet in height.

There are five level road-crossings, at each of which is built a lodge with gates.

GAUGE OF WAY, &c.—The line consists of a double way throughout, and at the Dublin station two additional lines are added; the whole width between parapets being about 54 feet. The general width of land occupied by the railway is about 76 feet, including the side-drains. Where the railway passes between parapet-walls, the clear width is 30 feet. On the sea-embankment there is a promenade towards the sea of about 18 feet in width, which is separated from the railway by neat iron railing, and from the sea by a stone wall. The gauge of way is 4 feet $8\frac{1}{2}$ inches, the intermediate space 7 feet $4\frac{1}{2}$ inches wide, and the width of each side-space 6 feet $7\frac{1}{2}$ inches.

The rails are of the parallel form, with flat bottoms, weighing 45 lbs. to the yard; the whole depth of rail being 4 inches, the top surface $2\frac{1}{2}$ inches wide, and the width of the base $2\frac{1}{4}$ inches. The rails are set in chairs, with 3-foot bearings; the chairs are 8 inches long by 9 inches wide, the rails being secured thereto with beech keys $9\frac{1}{2}$ inches long, and measuring $2\frac{5}{8}$ inches by $1\frac{1}{2}$ inches. These keys are cut with a circular saw worked by steam power, kyanized, baked at a temperature of 100° , and then compressed between rollers. Originally the whole way was laid with stone blocks; these, however, have been entirely taken up, and one line of way, in the autumn of 1839, had been relaid with longitudinal sleepers, and the other with transverse sleepers; though it was the intention of the Company, we understood, to have both lines laid with longitudinal timbers. The longitudinal sleepers are 12 inches wide by 6 inches thick, or what are termed half-timbers, and connected together with cross-ties dovetailed into longitudinal sleepers, as on the Great Western Railway, and fixed at intervals of 12 feet. Cross sleepers are partly used under the longitudinal timbers, as on the Croydon Railway. The transverse sleepers are 6 feet long, and measure 7 inches by 3 inches. The chairs are fixed to the transverse sleepers with 10-inch spikes. The rails

are in no case laid with continuous bearings, but are fixed in chairs, and rest on intermediate saddles. This plan has been lately adopted on the Birmingham and Gloucester Railway; but we are disposed to think that cross sleepers are infinitely preferable to longitudinal timbers, unless the rails in the latter case rest entirely upon the timbers. The cost of taking up the blocks and laying down longitudinal timbers is stated to have been 25*s.* per lineal yard.

The ballasting consists of broken limestone and gravel. The drainage is complete throughout the works. The fencing consists chiefly of stone walls, and earthen banks planted on the top with quick hedges, having open side-drains on the outside.

The cost of maintenance of way and works for one year, ending February 28th, 1839, was 1114*l.* 10*s.* 5*d.*, or about 185*l.* per mile.

STATIONS.—The Dublin station presents a neat elevation next Westland Row, extending 91 feet. It is in two stories, having three entrances to the booking-offices and waiting-rooms on the ground-floor. The passenger-shed is on a level with the upper floor, and is approached from the booking-offices by convenient staircases. There are four lines of way under the shed; the arrival-lines being separated from the departure-lines by iron railing. Convenient passages are formed from one platform to the other by the use of drawbridges, which are readily lifted for the passage of a train.

There are five intermediate stations, which are at Merrion, Booterstown, Williamstown, Sydney Parade, and Salthill and Blackrock. The buildings are of neat but unpretending design. The Salthill station is built in the cottage style, and has an exceedingly pleasing appearance. At Kingstown there are two offices; one for the arrival, the other for the departure-passengers. Besides the double way, there is a siding on the arrival-side terminating in a large turn-table of 14 feet diameter. Next to the siding there is a wooden platform for the arrival-passengers; and on the other side, next to the departure-line, another platform of sufficient length for nine carriages, and 10 feet wide. These platforms are 2 feet 2 inches above the level of the rails.

CARRIAGE-DEPARTMENT.—On our last view of this railway, in the autumn of 1839, the stock of carriages consisted of fifty-seven, including first-class, second-class, closed second-class, and third-class carriages. Some of the first-

class carriages have been in use since the opening of the railway. They are divided into three compartments, each to hold six passengers ; and lined and stuffed in the usual way. The length is 14 feet, and width 6 feet. The weight of a first-class carriage, including wheels, is about 4 tons. The wheels at present in use weigh about 20 cwt. per set, and cost 28*l.* 10*s.* The springs used are 5 feet in length ; a set of springs weighs 336 lbs., and the cost is stated to be 9*l.* 16*s.* The whole weight of iron in one of these carriages, including wheels, is estimated at two tons ; and the total cost, including wheels and springs, 358*l.* The bodies of first-class carriages are painted purple-lake, and the carriage vermilion. Spring-cushions have lately been introduced into some of the first-class carriages.

The second-class carriages are of two descriptions, close and open. The second-class closed carriages are superior to any at present in use on any railway in the United Kingdom. The elevation is more like that of a first-class carriage. They are in three compartments, each calculated to hold eight persons. Besides the glass in each door, there are six square side-lights on each side of the carriage. These carriages are painted pale patent yellow. The second-class open carriages, which are painted green, are covered with a roof and closed at each end, but open at the sides. They are in four compartments, three of which will hold eight persons each, and the fourth half that number—altogether twenty-eight. They are furnished with two footboards all along on each side, 10 inches wide ; the lower one is 18 inches above the rails, the upper one being of the same height from the lower footboard ; the length is 17 feet, the weight 3 tons 5 cwt., including wheels, and the cost 318*l.* 6*s.*

The original third-class carriages are 14 feet, and the modern 16 feet in length, and 6 feet wide ; and are divided into three large compartments and one small one. Each seat is intended to hold five persons ; the whole number, therefore, is thirty-five. They are closed at top and at each end. The gross weight of a third-class carriage, including wheels, is 2 tons 15 cwt. They are painted prussian-blue. All the carriages are numbered.

The luggage is carried in a separate carriage called a luggage-truck, or lorry ; it is 12 feet long, 6 feet 6 inches wide, and weighs about 30 cwt., the cost being about 50*l.*

The carriage-trucks are 15 feet in length, and 6 feet 3 inches wide,

There is an opening of 4 feet 2 inches in the middle of each side, and a moveable iron bar across each opening.

The wheels used for the carriages are 3 feet in diameter, and of cast iron, with wrought tires.

The framing of the carriages is all of Irish or Welsh ash, and the sheeting, or linings, of mahogany.

All the carriages are furnished with Mr. Bergin's patent spiral-spring buffers.

The carriage-department is under the direction of Mr. Heydn, who has shewn considerable taste in the design and finishing of the carriages. The establishment for repairing and building carriages is contiguous to the locomotive engines' station, which is situated on the right side of the line, and about half a mile from the Dublin station. The carriage-shed has three lines of way, which communicate with the main line by turn-tables on a siding in front of the building. Each of the three entrances has folding-gates. Behind this shed is a carriage-shop and smithy with five hearths. There are also a body-shop and paint-loft, with trapways in the floors for raising or lowering the bodies, or other parts of the carriages, from one floor to another.

There are about sixteen men in this department, whose wages vary from 2*s.* 8*d.* to 5*s.* 10*d.* per diem; and eight boys, whose wages are from 4*s.* to 8*s.* a-week.

The cost of repairs, wages, &c. of fifty-nine carriages for one year, ending February 1839, amounted to 2947*l.* 17*s.* 8*d.*

LOCOMOTIVE ENGINES.—On our visit to this railway in September 1839, there were nine locomotive engines belonging to the Company, viz. the Victoria, the Vauxhall, the Comet, the Star, the Hibernia, the Manchester, the Britannia, the Dublin, and the Kingstown; and three more had been ordered, with outside cylinders, and tanks attached to the machines.

The Victoria, the Vauxhall, and the Comet, have each 11-inch cylinders, 18-inch stroke, and six wheels, and weigh, including tank which is attached to the machine and 600 gallons of water, 14 tons. The wheels of the Victoria and the Comet are four, each of 5 feet diameter, and two of 3 feet 6 inches; and those of the Vauxhall are two (driving) of 5 feet 6 inches, two of 3 feet 6 inches, and two of 3 feet.

The Star weighs 9 tons 10 cwt., has 11-inch cylinders, 18-inch stroke, and six wheels, the driving being 5 feet 3 inches diameter, and the bearing-wheels 4 feet and 3 feet respectively.

The Hibernia, the Manchester, the Kingstown, and the Britannia, are of the same weight as the Star, have 11-inch cylinders and 17-inch stroke, and each six wheels, the driving being 5 feet diameter, and the bearing-wheels 3 feet 6 inches and 2 feet respectively.

The Dublin is of the same proportions as the Victoria, but without the water-tank attached, and weighs 9 tons 10 cwt.

The Dublin, Kingstown, and Vauxhall, were built by Messrs. Forrester and Co., of Liverpool, and have outside horizontal cylinders; and the Manchester, Hibernia, and Britannia, were built by Messrs. Sharp, Roberts, and Co., of Manchester. The two latter have outside vertical cylinders. Some of the engines are fitted with Mr. Melling's patent gearing.

The original cost of the engines is stated to have been about 1000*l.* each. The engines, most of which have been on the line from its first opening, have, however, generally been considerably altered from their original designs. The usual working pressure is 50 lbs.

The tenders are five in number; and with complement of fuel and water, each weighs about 5 tons. The steam is not allowed to blow off, but is injected into the tank to raise the temperature of the water. This plan is adopted also on the Dundee and Arbroath Railway.

The coke used on this line is from the Dublin Gas Works, and is supplied at 17*s.* per ton. Mr. Melling considers that about five per cent less caloric is produced from it than from Worsley coke. In calm weather the usual consumption of coke for a double trip of about twelve miles is 22 bags; but with a strong wind about 28 bags.

The following statement as to the consumption of coke on this railway, was kindly furnished us by Mr. Bergin, the secretary.

From December 1834 to March 1836 —

The Dublin ran in 303 days 5660 trips, each of 5½ miles, and consumed 1,000,043 lbs. of coke, or 176·68 lbs. per trip, including lighting of fires in the mornings; the net consumption being 138·68 lbs.

The Kingstown, in 307 days, ran 5976 trips, the net consumption of coke per trip being 143·60 lbs.

The Vauxhall, in 282 days, ran 5488 trips, and consumed per trip 152 lbs. of coke.

The Manchester made 5367 trips in 284 days, and consumed on an average per trip 137·70 lbs. of coke.

The Hibernia, which was rather out of order, ran 4917 trips in 290 days, and consumed 172 lbs. of coke per trip.

The Britannia ran 2205 trips in 140 days, and consumed on an average 129·50 lbs. of coke per trip.

Thus the number of trips performed by these six engines amounted to 29,613, or 167,807 miles; the consumption of coke being 4,347,573 lbs., or $\frac{1}{4}$ ths of a pound per ton per mile.

Mr. Bergin reckons that the profitable load, taking the average of the passenger-trains on this railway, is only about $\frac{1}{4}$ th of the gross load.

The locomotives-station is about half a mile from the Dublin terminus : it is entered by a siding on the right of the railway, which is terminated by a curved stop, 4 feet in height ; the siding has three turn-tables, from which cross lines run into the engine-shed, which stands nearly parallel to the railway ; the engine turn-tables are 14 feet in diameter. In the front of this building there are ten archways, each of 9 feet opening, the piers being each 4 feet in width ; within are standings for ten engines, with a race to each, 4 feet wide and 2 feet 9 inches deep, the bottom being paved, and having a good current to the cesspool.

The turnery, brass-foundry, boiler-plate furnace, smith's shop with eleven forges, and foundry, are all conveniently arranged ; the machinery is worked by a 20-horse engine, constructed by Fenton and Murray, of Leeds. The number of fitters employed in the locomotive department is twenty-five, earning from 9s. to 42s. each per week ; one stationary engine-man and stoker ; eight locomotive engine-drivers, who earn when on the line 6s. a-day, the working hours being from 6 A.M. to 11 P.M. ; and eight firemen, whose wages are 18s. a-week when out, and 12s. when in-doors ; there are also two watchmen, who earn 18s. a-week each.

The cost of locomotive power, for the year ending February 1839, amounted to 8,798*l.* 8*s.* 9*d.*, including 2,648*l.* 17*s.* 2*d.* for fuel, 777*l.* 12*s.* 11*d.* for wages to engine-drivers and firemen, and 727*l.* 8*s.* 4*d.* for oil, tallow, paint, and wages at coke-station, &c.

FARES, TRAINS, &c.—There are twenty-two trains daily in each direction: the fares throughout are, for first-class passengers, 1*s.*; second-class passengers, 9*d.*; and third-class passengers, 6*d.* Until May 8th, 1839, the second-class fare was 8*d.*; but by a considerable majority of votes, at a special meeting held on the 12th of April, it was determined to raise it to 9*d.*; the consequence, however, has been a falling off in the number of passengers.

To shew how steadily the traffic has increased on this line until the alteration took place in the second-class fares, it is only necessary to add the following statement:—

	No. of Passengers.	Receipts.
Year ending 29th February, 1836 . . .	1,123,971 . . .	£30,992 11 2
„ 28th February, 1837 . . .	1,184,428 . . .	32,138 9 4
„ „ 1838 . . .	1,243,972 . . .	33,880 7 8
„ „ 1839 . . .	1,326,830 . . .	35,307 13 8
„ „ 1840 . . .	1,280,763 . . .	34,175 15 5

RECEIPTS AND EXPENDITURE.—The receipts for the year ending Feb. 28th, 1839, amounted for—

Passenger-traffic to	£34,408 17 0
Parcel-traffic	307 9 8
Baths, net	91 7 0
Post-office contract	500 0 0
	<u>£35,307 13 8</u>
The expenditure for the same period amounted to . . .	20,453 15 3
Leaving gross profit for one year	<u>£14,853 18 5</u>

This railway was laid out and carried into execution under the direction of Mr. Vignoles, and does him very great credit; Mr. Woodhouse, now of the Midland Counties Railway, being the resident engineer during the execution of the works.

DURHAM JUNCTION RAILWAY.

THE Durham Junction Railway is celebrated on account of the elegant Victoria Bridge, which carries it over the river Wear, near Low Lambton. The line, as originally laid out, was intended to form a junction with the north end of the Hartlepool Railway; but at present it only extends as far as the Seaham Railway, in the township of West Rainton. The whole length of this way, from its junction with the Stanhope and Tyne Railway to that of the Seaham line, is 4 miles 70 chains.

COURSE OF THE RAILWAY. — Leaving the Stanhope Railway, with a curve of about 27 chains radius, it passes through part of the parish of Washington, crossing the river Wear; and with another curve, of about 20 chains radius, to near New Painshaw, continues thence, nearly in a direct course, a little to the north-east of Biddick Blue Houses, where, with a curve of about a mile radius, it passes on to Elba; thence taking nearly a direct line to the south-east of New Lambton, close to the Fence Houses, in Morton township; from whence intersecting the townships of Houghton, East Rainton, and West Rainton, it terminates in the latter at the Seaham Railway.

INCLINATIONS. — Commencing at the Stanhope and Tyne Railway, the following are the planes and inclinations in order:—

Miles.	Chains.		Ratio.
	55	. . . . . level.	
1	01	. . . . . ascending	. . . . 1 in 329
1	06	. . . . . level.	
2	08	. . . . . ascending	. . . . 1 in 267

With regard to inclinations, therefore, this line is very favourable, and comes under the second class. The gauge of way over the Victoria Bridge is 4 feet 8½ inches; intermediate space, 4 feet 4½ inches; and side-spaces, each 3 feet 9 inches wide.

The rails are of fish-bellied form, 40 lbs. to the yard; the stone blocks

are placed diagonally, as on the London and Birmingham Railway. The rails were supplied by Bailey Brothers, at 8*l.* 7*s.* 6*d.* per ton.

There are comparatively few bridges on this line of way. The Victoria Viaduct, already alluded to, is of plain but neat design, and consists of four large and six small arches: the river-arch is of 160 feet span, the adjoining arch is only 144 feet, the next arch on either side is 100 feet, and the three land-arches on each side 20 feet in span; the middle pier is 23 feet 9 inches, and the other large piers 21 feet 6 inches in width; the length of a pier is 54 feet from point to point, and above the springing of arches 31 feet in length. Each pier has three courses of footings, altogether 5 feet high; the piers are not solid, but built with cross walls up to the springing level; over the arches are introduced spandril and cross walls; the whole being flagged over to receive the road-materials. The piers are grounded on the solid rock; but the south abutment being over quicksand, required to have an artificial foundation of piles, sleepers, and 3-inch Memel planking, in two thicknesses; the piles are of Scotch fir, 10 inches diameter and 14 feet long, and driven 3 feet apart. The lowest part of the foundation is 40 feet below the ordinary flood level. The whole length of the bridge is 811 feet 9 inches; and the top width, including parapets, which are solid and 4½ feet high, 23 feet 3½ inches.

Mr. Harrison, the engineer, informed us that its actual cost was 38,000*l.*, the original contract being 34,619*l.* The average cost per cubic foot of stone, including coffer-dams, &c., he finds to have been one shilling. By the original design, which included two large instead of the six small arches, the bridge would have been 135 feet longer than it really is; the original estimate for which was 50,000*l.*

The two larger arches are built of Pensher stone, and the quoins of Aberdeen granite. All the rest of the bridge is built of stone from Pensher Quarry, which is about 1½ miles from the bridge.

The whole was contracted for and executed by Mr. Gibb, of Aberdeen. The works were commenced on the 17th March, 1836, and finished on the 28th June, 1838. The embankment contiguous to the north abutment we perceived was rather in a slippery state on our visit to this work in the autumn of 1839.

The Act of incorporation received the royal assent on the 16th June, 1834, and gave the Company power to raise 114,000*l.*, of which 80,000*l.*

was to be in joint-stock, and the remainder by loan. By a subsequent Act, dated 3d July, 1837, the Company were authorised to raise an additional sum of 12,000*l.* in joint-stock, and 4000*l.* by loan: the total sum thus authorised to be raised amounting to 130,000*l.*

DURHAM AND SUNDERLAND RAILWAY.

THE Durham and Sunderland is the longest public railway in the kingdom worked entirely by the fixed-engine system, and exhibits clearly the inefficiency of this plan for passenger-traffic. The difficulty of starting the trains, the numerous detentions on the way, and the great uncertainty of the time that a journey will occupy, added to the jolts experienced by passengers when reaching a bank-head, or when making a false start,—a thing of very frequent occurrence,—all present themselves as serious objections to the stationary system.

Much, no doubt, depends upon the signals in use; and we should consider money well laid out, on a railway worked entirely by ropes, in laying down from station to station either the electro-galvanic, the hydraulic, or the pneumatic telegraph; by either of these plans the most complete and rapid communication may be held between persons far apart, both by sound and by sight: the cost of a single line of communication is from 200*l.* a-mile upwards.

The first Act of Parliament for the construction of this line received the royal assent on the 13th August, 1834, by which the Company were allowed to raise in joint-stock a capital of 102,000*l.* By another Act, obtained in July 1837, which received the royal assent on the 3d of that month, the Company were authorised to raise an additional capital in joint-stock of 90,000*l.*, and by loan 64,000*l.*, making the total 256,000*l.*

COURSE OF RAILWAY, &c. — Commencing at the station on Sunderland Moor, this line proceeds by Ryhope and Seaton to Merton, at which place

the Haswell and Durham branches diverge; the former being in direct communication with the Hartlepool Railway, and the latter continuing on to Sherburn, which is the station for Durham, and to and from which city the passengers are conveyed by a stage-coach.

There are altogether eight planes, varying in inclination from 1 in 60 to 1 in 264. The first, or Ryhope plane, is 5616 yards in length; the second, or Seaton Incline, 4485 yards; and the third, or Merton, 2427 yards. These three planes are all ascending towards Merton junction. The planes descending from thence are, first, that to Appleton, 1227 yards; next, to Hetton, 1585 yards; the third, to the road leading to Alexander Pit, 2850 yards; the fourth, that to Piddington Railway, 1400 yards; and lastly, the Sherburn plane, 3712 yards in length. Thus the whole length of planes is 23,302 yards, or 13·23 miles.

EARTHWORKS, BRIDGES, &c. — Some of the embankments on this railway are formed chiefly of small coal, which is, perhaps, the best material that can possibly be used for this purpose; the cost is stated to have been 9*d.* per cubic yard: except, however, in the largest coal-districts, its use is entirely precluded by the cost of carriage. The width of cuttings is about 28 feet at level of rails. The deepest cutting on the line is at Shincliffe, through loose clay and sand; its length is about 25 chains, and greatest depth 60 feet, the slopes being $1\frac{1}{2}$ to 1.

Considerable difficulty is experienced in preventing slips in some of the cuttings, where the material is of soapy clay and loose sand. Wooden troughs are used on the slopes to carry off the water into the side-drains below. In some cases, the foot of the slope is paved; but this alone will never prevent the upper portions of such slopes from slipping. We are fully persuaded, that in laying out a railway, the length had better be considerably increased, if it is possible thereby to avoid any extent of such treacherous material, which incurs a constant annual outlay, and is sometimes the cause of the railway being entirely stopped for hours together.

The bridges over a railway worked by ropes are necessarily not required to have their arches so high as when over a locomotive's line, the height in that case being regulated by the height of the engine's chimney: hence, in a

long line there would be a considerable saving in the item of bridges on this account.

GAUGE OF WAY, &c. — The gauge is 4 feet $8\frac{1}{2}$ inches; and where there are two lines of way, the intermediate space is 4 feet 5 inches. In some parts, where the ascending and descending trains do not pass each other, there are three rails only; and at the bank-tops there are four lines of way. The rails are of different kinds; some of cast iron, and of fish-bellied form, $6\frac{1}{2}$ inches deep in middle, $2\frac{1}{2}$ inches wide at top, and the upper web being $1\frac{1}{2}$ inches thick; they are in 4-feet lengths, some weighing 84 lbs. each, and others 68 lbs. There are also wrought-iron single parallel rails on the embankments, weighing 42 lbs. to the yard; these are fixed with 3-feet bearings in joint-chairs, each weighing 14 lbs., and intermediate chairs 10 lbs. This latter description of rail was furnished by Losh, Wilson, and Bell, at 11*l.* per ton.

There is an entire absence of stone blocks throughout this line; cross sleepers of larch-logs, 7 inches diameter, are used both in cuttings and on embankments; those to which joint-chairs are secured being 8 feet long, and the others 7 feet: the cost of the former being 2*s.* 3*d.*, and of the latter 1*s.* 9*d.* each.

The ballast is of small coal throughout; the fencing consists chiefly of posts and three rails.

STATIONARY ENGINES. — To work this railway, there are eight fixed engines: the first, or Sunderland engine, being of seventy-horse power; the second, or Seaton Bank-top, forty-two horse; the third, or Merton, seventy horse; the fourth, or Appleton, eighty-three horse; the fifth, or Hetton, forty-two horse; the sixth, or Moorsley, fifty-two horse; the seventh, or Piddington, eighty-five horse; and the eighth, or Sherburn, also of eighty-five horse power. Thus the united power is equal to that of five hundred and twenty-nine horses. The men employed in this department are nine engine-men, at 24*s.* a-week each; twelve stokers, at 18*s.*; and nine drummers, at 14*s.* each per week.

The first plane, ascending from Sunderland to Ryhope, is worked by three ropes; two being each 2450 fathoms in length, of $5\frac{1}{2}$ inches circumfer-

ence, and weighing together 43,200 lbs.; and the third $4\frac{1}{2}$ inches circumference, and weighing 13,216 lbs., and also 2450 fathoms long.

The Seaton plane is worked by one $7\frac{1}{4}$ -inch rope, 2,325 fathoms in length, and weighing 32,588 lbs.; the rope is drawn out by the wagons descending by gravity.

The Merton Incline has two ropes; the one a 5-inch, 1250 fathoms in length, and weighing 8333 lbs.; the other of $6\frac{3}{4}$ inches circumference, 575 fathoms in length, and weighing 6986 lbs.

The fourth plane is worked by one rope for the ascending, and by gravity for the descending wagons: this rope is of $6\frac{3}{4}$ inches circumference, 740 fathoms in length, and weighing 8990 lbs.

The fifth incline is also worked by one rope, which is of $4\frac{1}{2}$ inches circumference, 1425 fathoms in length, and weighs 7694 lbs.

The sixth plane has two ropes; the one being of the same length and weight as the last; and the other being 700 fathoms in length, $5\frac{1}{4}$ inches in circumference, and weighing 5124 lbs.

The seventh and eighth planes are each worked by a single rope; the length of each of which is 2450 fathoms; the size of the seventh being $5\frac{3}{4}$ inches, and the weight 21,600 lbs.; and of the eighth, 4 inches, and the weight 15,120 lbs.

The whole weight of ropes, therefore, is 170,545 lbs., or 76·13 tons.

Mr. Blenkinsopp, the engineer of this railway, estimates the cost of these ropes at 40*l.* per ton, and their average duration about nine months. In this case, the annual cost for ropes on this line would be 2283·90*l.*, or 172·63*l.* per mile.

At level road-crossings, the ropes run in channels properly constructed for the purpose.

The rope-sheaves are of cast iron, weighing 28 lbs. each, 12 inches in diameter and 7 inches wide; some of them being fixed in cast-iron standards, and others in wooden boxes, at intervals of 18 and 24 feet respectively. In curved portions of the line they are inclined to the horizon. At night the way is lighted by large fire-lamps, three at each bank-head.

CARRIAGES.—The carriages for the conveyance of passengers, which were furnished by Mr. Usher, of Newcastle, are of two kinds, mixed and second-

class; the mixed having one first-class compartment in the middle, which is closed on each side, and two second-class compartments open on each side; and the second-class carriages having each three compartments, all open at the sides. The fares, however, are the same, whether for the open or closed compartments. These carriages have each a narrow iron footboard the whole length on each side. The luggage is carried in lockers under the seats. The passenger-carriages always accompany coal-trains.

In 1838, the number of passengers conveyed on this line amounted to 77,421; and the receipts on account of passengers and parcels to 2024*l.* 18*s.* 9*d.*

WAGONS.—The wagons used on this line belong to the coal-owners; they are constructed generally of wooden framing, lined with plate iron. The weight of a wagon is about 30 cwt.; and the cost is stated to be 25*l.*

The usual train consists of twenty-four wagons laden in one direction, and the same number empty in the other direction. The average speed of the trains is about 8½ miles per hour, when the whole is in good working condition, and the signals properly given. The stoppages average about four minutes each.

There are about twenty men to keep the way in repair, including labourers. The waymen receive 25*s.*, and the labourers from 12*s.* to 18*s.* a-week each. The whole, however, is under a contract at 25*l.* a-week, or 1300*l.* per annum. The way-leaves amount to 5000*l.* a-year, or nearly 378*l.* per mile.

This railway is altogether under the direction of Mr. Blenkinsopp, who appears to be thoroughly acquainted with the fixed-engine system; and who evidently pays considerable attention to the interests of the Company for which he is engaged.

DUNDEE AND ARBROATH RAILWAY.

PARLIAMENTARY estimates for railways have naturally caused much inconvenience and disappointment to a large class of shareholders. No engineer, we are inclined to think, who gave the subject proper consideration, would omit in his estimate the cost of stations, locomotive engines, and carriages; for of what use is the railway without the means of working it? An estimate for this purpose should include every thing necessary to put the railway into complete working condition: the promised returns, without this necessary precaution, are but as glittering bubbles floating for awhile in the atmosphere of attraction, but presently bursting on the ground of deception. Many are the cases in which this essential part of a parliamentary estimate has been omitted, but we shall here notice no individual cases; it is enough at the present to warn engineers in future to avoid this dangerous rock, on which they will one day assuredly split, if they take not heed of the beacon in due time.

Messrs. Grainger and Miller, under whose directions the Dundee and Arbroath Railway was constructed, are among the few engineers who have ventured on a new gauge. This is the more remarkable, as they had already used, in three other railways in Scotland, a gauge even less than 4 feet 8½ inches. We object to any alteration of gauge, where a line is likely to become a link of any long chain of railway-communication already established; but whether this railway is likely in future years to be so circumstanced, we have not at present the means of judging.

The Dundee and Arbroath Railway Company obtained their Act of incorporation on the 19th May, 1836. It enabled them to raise a joint-stock capital of 100,000*l.*, and an additional sum of 40,000*l.* by way of loan.

COURSE OF THE RAILWAY.—Commencing at Trades Lane, Dundee, the line skirts the coast for more than two-thirds of its whole length, passing in its course West Ferry, Broughty Ferry, and Milton, from whence it continues in a direct line to the village of Carnoustie, thence to West Haven and East Haven; and nearly skirting the shore, terminates at the Arbroath station near the Harbour, where it joins the Arbroath and Forfar Railway. But, strange

to say, for these two short lines there are two independent stations at Arbroath !

CURVES AND INCLINATIONS.—The quickest curves are at East Haven, of about three-quarters of a mile radius ; a second, approaching Arbroath, of similar radius ; and a third, at Seaforth, of about 25 chains radius. With these exceptions, the line in point of curvature is very favourable. With regard to inclinations, this is one of the few railways in the kingdom so nearly approaching to a level throughout. The whole distance from Dundee to Arbroath is 16 miles 50 chains.

EARTHWORKS, BRIDGES, GAUGE, &c.—The earthworks are but light throughout. We counted five bridges over the railway, ten bridges under, nine level road-crossings, and forty level field or occupation-crossings.

The rails, and mode of fastening them, are the same as on the Arbroath and Forfar Railway (see Plate III. fig. 1). The line is laid with stone blocks and cross sleepers.

The ballast is of gravel. The fencing consists of posts and three rails, and of stone walls.

The gauge of way corresponds with that of the Arbroath and Forfar Railway, which is 5 feet 6 inches ; the intermediate space is 6 feet 5 inches wide, and each side-space 6 feet $3\frac{1}{2}$ inches.

STATIONS AND DEPÔTS.—Besides the terminal stations, there are five intermediate stations, which are at Roodyards, Broughty Ferry, Monifieth, Carnoustie, and East Haven. The buildings, where erected, are of neat appearance, being in the Gothic style of architecture. That at Carnoustie is a small cottage, a building suited to the traffic of the place. At Arbroath there is a double way under the passenger-shed, which is covered with a high-pitched Gothic roof. The platform, which is on the arrival-side, is returned at the end ; it is 7 feet 2 inches in width, projecting one foot over the inner side-space, the clear width of shed being 32 feet. At the end of the rails there is a wooden carriage-stop, formed of two upright timbers, 8 inches square and 3 feet 4 inches high, being 3 feet 10 inches apart, and a longitudinal head-plate measuring 4 inches by 8 inches, and projecting over at each end. The booking-office and waiting-room are between the platform

and the street. Outside and parallel to the shed there are four additional lines of way; the two nearest to which continue on to join the Arbroath and Forfar Railway, and the outer line runs into the engine-house. On the third line of way from the shed there is a weigh-bridge, 7 feet 7 inches long and 7 feet wide. There are also two turn-tables, one for carriages, 11 feet 6 inches diameter, on the arrival-line outside the shed; and the other for engines, 13 feet 4 inches diameter, on the line leading from the engine-house. In the engine-house there is a blower suspended from the roof, for drawing the fires of the engines when first lighted.

CARRIAGES.—The carriages correspond with those of the Forfar line. They consist of first-class, mixed, and third-class carriages. The first-class carriages weigh each 3 tons 6 cwt.; the mixed, 3 tons 8½ cwt.; and the third class, 2 tons 9 cwt. There are curtains to the second-class compartments of the mixed carriages. The luggage-vans weigh each 2 tons 4 cwt. The carriages are severally furnished with a footboard along each side, with steps above.

The wheels are of wrought iron, 3 feet in diameter, from Lilly Bank Foundry, Dundee, and cost 30*l.* a set.

The carriages have names, as on the Liverpool and Manchester and Grand Junction Railways; the first class are called the Antiquary, Panmuir, Broughty Castle, and Patrick Robertson; the mixed are called the Antelope, Stag, Dolphin, and Eagle; and the third class, Orchiltrie and Mucklebucket.

LOCOMOTIVE ENGINES.—The engines in use on this line are similar to those on the Forfar Railway. They are called the Wallace, the Griffin, the Fury, and the Rapid. They have 13-inch outside horizontal cylinders, 18-inch stroke, six wheels, viz. driving, 5 feet, and four bearing-wheels, each of 3 feet 6 inches diameter. The Rapid cost 1270*l.*, each of the others 1012*l.*, including tenders. The tenders weigh 3 tons 6 cwt. net; and with complement of fuel and water, 5 tons 2 cwt. each.

The steam is not allowed to blow off to waste, but is admitted into the tank of tender, to raise the temperature of the water, as on the Dublin and Kingstown Railway.

The average velocity of the engines is about 21 miles an hour; but in parts of the journey it is considerably above 30 miles an hour. The trains consist usually of three mixed carriages, two first-class, and one third-class carriage with luggage-compartment.

The line was first opened in the latter part of 1838 for about 14½ miles, commencing at a temporary station about 2½ miles from Dundee, and the number of passengers travelling on the line for the first eight months of its being opened amounted to 55,173, the receipts for that time being 3713*l.* 19*s.* ½*d.*; the number increasing from 6713½ in the first month to 9477 in the eighth month.

For six months, ending 30th April, 1839, the receipts for			
passengers' fares amounted to	.	.	£3,013 2 10½
Parcels	.	.	62 1 8
Merchandise	.	.	12 17 3½
			<hr/>
			3,088 1 10
Interest	.	.	15 14 1
			<hr/>
			£3,103 15 11

The expense of working the line for this period, including			
omnibus hire between the temporary station and Dundee			
of 381 <i>l.</i> 15 <i>s.</i> 1 <i>d.</i> , amounting to	.	.	1,768 18 6½
			<hr/>
Leaving a clear profit for six months of	.	.	£1,334 17 4½

By the above statement it will be seen, that the expense of working the line amounted to upwards of 56 per cent on the revenue. It shews that there is little gained by opening a line before the arrangements are quite complete.

Up to 1st May, 1839, the disbursements amounted to 109,807*l.* 6*s.* 7*d.*, and the receipts to 109,923*l.* 17*s.* 9*d.*

The following note of salaries paid to the principal officers of the Company may be useful as a guide for new companies in Scotland.

Manager	.	.	.	.	.	.	per annum	£315	0	0
Secretaries	.	.	.	.	.	.	"	75	0	0
Resident engineer	.	.	.	.	.	.	"	300	0	0
Accountant	.	.	.	.	.	.	"	110	0	0
Arbroath-station clerk, with dwelling	.	.	.	.	.	.	"	80	0	0
Intermediate-station clerk, with dwelling	.	.	.	.	.	.	"	50	0	0
Intermediate-station clerk, without dwelling	.	.	.	.	.	.	"	60	0	0

DUNDEE AND NEWTYLE RAILWAY.

THERE are three railways in Great Britain which, from the peculiarity of each having been worked by three different kinds of power, and none of them being famed as lucrative concerns, deserve to be noticed together; these are, the Canterbury and Whitstable, the Bolton and Leigh, and the Dundee and Newtyle Railways. Stationary engines, locomotive engines, and horses, have been used conjointly on each of these lines in transferring loads from one end of the line to the other.

Three Acts of Parliament have been obtained by this Company; the first received the royal assent on the 26th May, 1826, by which a capital in joint stock of 30,000*l.* was authorised to be raised, and an additional sum by loan of 10,000*l.*; the second Act received the royal assent on the 29th May, 1830, by which an addition to the joint stock was allowed to be raised of 10,000*l.*, and by loan 20,000*l.*; and the third Act, which received the royal assent on the 4th July, 1836, empowered the Company to raise an addition to the joint-stock capital of 100,000*l.*; making a total of 170,000*l.*

The railway between Dundee and Newtyle is carried from the harbour of Dundee over the Sidlaw Hills into the Vale of Strathmore, and is in communication with two other lines, called the Newtyle and Coupar Angus and the Newtyle and Glamis Railways. From the harbour of Dundee, a single line of way is laid, on the level of the streets, to the Dundee station, from which the line at once rises with an inclination of 1 in 10, for a distance of about 42 chains; from this point the line runs on a level for about 4·75 miles, and thence the second incline rises to the summit level at the rate of 1 in 25 for 77·27 chains; the summit level is 4·75 miles long; and between its termination and Newtyle, the line descends at the rate of 1 in 13 for 45·45 chains.

There are several quick curves in this line of from 90 feet to 500 feet radius.

GAUGE OF WAY, RAILS, &c.—The gauge of way is 4 feet 6½ inches. The rails are of fish-bellied form; some weighing 28 lbs., and others 35 lbs. to the

yard; they are fixed in chairs, with 3-feet bearings, the rails being secured to the chairs with small iron keys; the freestone blocks on which the chairs are based measure 1 foot 10 inches square, and 10 inches thick for the intermediate chairs, and 2 feet square and 10 inches thick for the joint-chairs; the weight of an intermediate chair is 10 lbs. The rails were furnished by Longridge and Co., of the Bedlington Works, at from 12*l.* to 18*l.* a ton!

The slopes of some of the embankments are thickly planted with trees. Open drains are used for embankments, and covered drains in cuttings. The fencing consists of stone walls, and of posts and rails.

The intermediate stations are four in number, having only temporary buildings of stone and wood. There is a tunnel through dislocated whinstone at the top of the Law Incline; it is 330 yards in length, 10 feet 2 inches high, and 10 feet wide, with only a single way through it. This work is stated to have cost about 5000*l.*

The line passes for about two-thirds of its length through the properties of the Earl of Airlie and Lord Wharncliffe.

STATIONARY ENGINES.—The planes worked by fixed engines are the Law, the Balbeuchly, and the Hatton Inclines.

The Law Incline, which is 1060 yards long, the ratio of inclination being 1 in 10, is laid with three rails at top, four in the middle, and two at the bottom. It is worked by a forty-horse high-pressure engine, having a cylinder of 21½ inches diameter; stroke, 5 feet; rope-roll, 12 feet in diameter; the pinion on fly-wheel shaft having thirty-two cogs, and the spur-wheel on rope-roll shaft ninety-seven cogs: the usual working pressure is 40 lbs. on the square inch. The ordinary loads are from twenty to twenty-four tons, including a ballast-wagon of four tons, which always accompanies the train in its ascent, and is furnished with a brake and clutches for the purpose of stopping the train in case of the rope breaking. The time occupied in the ascent is about six minutes. The counterbalance is of from ten to twelve tons weight. The cost of this engine is stated to have been 2750*l.* The rope is of 7½ inches circumference, and weighs 8960 lbs.

The Balbeuchly Incline, which has a single way only, is about 1700 yards in length, ascends at the rate of 1 in 25, and is worked by a twenty-horse condensing engine; cylinder, 26½ inches; stroke, 4 feet 6 inches;

usual working pressure of steam $4\frac{1}{2}$ lbs.; the pinion on fly-wheel shaft has 48 cogs; rope-roll 12 feet diameter; and the spur-wheel on rope-roll 97 cogs. The usual load is about 16 tons; the time occupied in the ascent being six minutes. This engine cost 1600*l*. The rope is of $5\frac{1}{2}$ inches circumference, 900 fathoms in length, and weighs 7056 lbs.

The Hatton Incline, which is also laid with a single way, descends to Newtyle, at the rate of 1 in 13, for a length of 1000 yards. It is worked by an engine similar to that for the Balbeuchly Incline. The pinion, however, has only 31 cogs, and the spur-wheel 94 cogs.

All the above inclines are straight; the sheeves are fixed at intervals of six yards.

The consumption of fuel for the three engines is about 85 tons per month: the coals used are from Preston Grange, east of Edinburgh, and cost 10*s*. a ton delivered on the line.

LOCOMOTIVE ENGINES. — The intermediate level planes are worked by locomotive engines, which are called the Earl of Airlie, Lord Wharncliffe, Trotter, and John Bull. The Earl of Airlie and Lord Wharncliffe were introduced on this line in September 1833. They have each 11-inch cylinders, and 18-inch stroke; six wheels, the driving-wheels being $4\frac{1}{2}$ feet in diameter, and the carrying-wheels, which are attached to a swivel-truck, or bogie-frame, of smaller size. The Trotter is a similar machine, and was supplied in March 1834. These engines were built by Mr. Stirling, of Dundee, and cost each 700*l*., exclusive of tender. The tenders are simply four-wheeled wagons with a water-butt at one end, and cost each 30*l*.

The John Bull, which is from the works of Messrs. R. Stephenson and Co., of Newcastle, has an eleven-inch cylinder, and sixteen-inch stroke; and four coupled wheels, each of 4 feet 4 inches diameter. The weight of the smoke-box end is 65 cwt., and of the fire-box end $78\frac{1}{2}$ cwt., together 7 tons 3 cwt. 2 qrs.; and when in working trim the smoke-box end weighs $67\frac{1}{2}$ cwt., and the fire-box end 96 cwt.: together 8 tons 3 cwt. 2 qrs. This engine was supplied in April 1836, and cost, including tender, 1137*l*.

The usual pressure of steam is 50 lbs. The coke used is from Carmichael's Foundry, Dundee, and is composed of Garesfield and Prudhoe Main Northumberland coal. The cost is 2*s*. 6*d*. per bowl of 192 lbs., or about 29*s*. per ton.

The consumption of coke for two engines in the month of August 1839 was 105,600 lbs.

The engines start simultaneously at the top of the Law and Hatton Inclines, one engine working each of the level intermediate planes: a trip to and fro is, therefore, about $9\frac{1}{2}$ miles.

CARRIAGES.—The carriages consist of first-class and mixed vehicles: the first-class have three compartments, each holding eight persons; the mixed carriages resemble an ordinary stage-coach, with the addition of an entirely open compartment both before and behind; the middle compartment, which holds only four passengers, is called the extra first class; and each of the open compartments holds eight passengers: altogether twenty. The wheels are 3 feet in diameter, of cast iron, with case-hardened tires; each wheel weighs from $2\frac{1}{2}$ to $2\frac{3}{4}$ cwt., the cost being 7*l.* 15*s.* per set. The first-class carriages cost from 80*l.* to 90*l.* each, and the mixed from 60*l.* to 70*l.*

The wagons belonging to this Company are about 110 in number, besides 60 trucks. The wagons weigh each 24 cwt., and are constructed of plate iron on wooden framing.

The weight of coals allowed to be taken by each wagon is three tons; the gross load, therefore, is 4 tons 4 cwt. The average cost of the wagons is 20*l.* The wheels are the same as those used for the carriages. When this railway was first opened, the wagons were constructed without springs.

THE ESTABLISHMENT.—The following account of the number of persons employed on this railway, with their salaries and wages respectively, cannot fail to be useful to the directors of future similar works in Scotland.

	Per annum.
Manager	£70 0 0
Two collectors	{ 65 0 0
	{ 50 0 0
Tonnage-master	50 0 0
Accountant	50 0 0
Ticket-clerk	40 0 0
Superintendent at Newtyle	50 0 0
and Boy	26 0 0
Two superintendents of traffic	104 0 0

	Per annum.
Superintendent of engines	78 0 0
Three stationary engine-men	119 12 0
Three stokers	78 0 0
Two bank-riders	62 8 0
One man and horse, top of Law Incline	78 5 0
One man and horse, top of Balbeuchly Incline	78 5 0
Two locomotive engine-drivers	93 12 0
Two firemen	62 8 0
Two train-men	62 8 0
Two guards	78 0 0
One policeman for Dundee Incline	31 4 0
One engine-fitter	39 0 0
and boy	15 12 0
Three smiths	109 4 0
One striker	31 4 0
Three wrights	109 4 0
and boy	7 16 0
Ten way-men	312 0 0
	<hr/>
	£1,651 2 0

FARES, TRAINS, &c.—The number of passenger-trains daily in the summer months is four in each direction, and in the winter only three. The fares between Dundee and Newtyle are respectively 18*d.*, 15*d.*, and 12*d.*

Before the construction of this railway, the Blairgowrie was the only stage-coach passing through this district; and that only two or three times a-week during the summer months.

To shew the increase of traffic which took place by the introduction of this railway, it is only necessary to subjoin the following statement :—

	Amount of goods conveyed.			Passengers.	Working expenses.
	tons.	cwt			
From 1st Dec. 1831 to 30th April, 1832	1,564	1	7,075	£400	0 0
Year ending 30th April, 1833	24,393	3	31,264	3,320	19 9½
" 1834	33,879	9	34,057	4,764	0 8
" 1835	38,323	10	51,366	4,719	7 4½
" 1836	43,824	13	57,141	4,931	8 1½

And in the year 1838 the passengers amounted to 59,682.

COUPAR ANGUS AND GLAMMIS BRANCHES.—In connexion with the Dundee

and Newtyle Railway, though not belonging to the same Company, are the Coupar Angus and Glammis Branches, which after running together for about a mile, with a descent of 1 in 100, diverge from the Dundee line at Newtyle in opposite directions. The distance from Newtyle to Coupar Angus is about $5\frac{1}{2}$ miles; and from Newtyle to Glammis $7\frac{1}{4}$ miles. Mr. William Blackadder, of Glammis, is engineer to both these branches.

It may be as well to state here, that that part of the railway running through the town of Dundee belongs to some few of the proprietors of the Dundee and Newtyle Railway.

THE EASTERN COUNTIES RAILWAY.

THE Eastern Counties, or, as it was originally called, the Grand Eastern Counties Railway, was intended, according to the prospectus of 1835, to afford the means of railway-communication to the inhabitants of no fewer than fifty-eight important towns and considerable villages in the counties of Essex, Suffolk, and Norfolk, containing an aggregate population, according to the last census, of 739,697 souls, or at the rate of about 5847 per mile of railway. At present, however, the rural terminus is at Warley Lane, lying between Brentwood and Warley Common, a distance from London of about eighteen miles. Indeed the Brentwood Hill appears at present to be a complete barrier to the further extension of the works; for just beyond this place there are no signs of setting out the line or enclosing the lands required for the railway.

The first Act of Parliament for the construction of this work received the royal assent on the 4th July, 1836, by which the Company were authorised to raise in joint stock a capital of 1,600,000*l.*, and by loan a further sum of 533,333*l.*, making a total of 2,133,333*l.*

COURSE OF THE RAILWAY.—Commencing at High Street, Shoreditch, a little to the south of Church Street, Bethnal Green, the line passes through Spitalfields, crossing Wheeler Street and Brick Lane, and thence continuing

through Mile End and crossing the Dog Row and Globe Lane, proceeds in a somewhat sinuous course to the right of the East London Water-Works at Old Ford; from whence, across the Marshes, it proceeds a little to the left of Stratford, where it intersects the Wanstead Road; thence continuing to the left of Ilford, it crosses the great Essex turnpike-road before reaching Romford, which is on the left. From Romford it runs nearly parallel with the turnpike-road until reaching its present termination at Warley Lane, Brentwood.

Commencing at the London terminus in Shoreditch, the following exhibits the length and inclination of each plane, as far as the summit at Brentwood, according to Bradshaw's Book of Levels:—

Lengths of Planes.				Ratio of Inclination.		Locations.	
Miles.	Chains.						
	22·00	. . . . .	level	. . . . .			Brick Lane.
	50·09	. . . . .	descending at the rate of 1 in	480			Cambridge Road.
	23·00	. . . . .	ascending	„	1 in	350	Charles Street.
2	79·20	. . . . .	descending	„	1 in	330	Maryland Point.
	10·10	. . . . .	level	. . . . .			Water Lane.
	64·25	. . . . .	ascending	„	1 in	406	Forest Gate.
	75·00	. . . . .	ascending	„	1 in	3335	Fry's Bridge.
4	02·20	. . . . .	ascending	„	1 in	406	Chadwell.
	33·60	. . . . .	level	. . . . .			Road to Hornchurch.
5	11·40	. . . . .	ascending	„	1 in	406	Putswell.
2	75·20	. . . . .	ascending	„	1 in	100	Brentwood.
18	46·04						

By examining the above table, it will be seen that the gradients are entirely of the first class, except the Brentwood Incline, which rises to the summit level with a gradient of 52·80 feet, for a length of nearly three miles. This incline would have been less objectionable, had there been a short level plane in the middle, to check the engines' velocity while making the descent.

EARTHWORKS, BRIDGES, &c.—From the end of the London viaduct, which extends to the temporary station in Devonshire Street, Mile End, the line runs on an embankment to Stratford, between which place and Brentwood it alternates in cutting and embankment. The great work in this depart-

ment is the cutting at Brentwood, which at present remains in a very unfinished state. The slopes throughout the finished portions are in good order; nor do slips at present appear to have given much trouble to the engineer.

On our view of this railway, we counted twenty-two bridges over, and seventeen under the railway, exclusive of the London viaduct.

The level road and field-crossings are comparatively few; and where footpaths cross on a level, they appear to be attended by policemen.

The London viaduct is decidedly a heavy work; and the engineer, Mr. John Braithwaite, has determined that it shall stand for ages, for it is built in a very substantial style. This viaduct, which consists of 160 arches of from 36 to 62 feet in span, is about a mile and a quarter in length; it is constructed chiefly of brickwork, the arches being turned in cement; but the crossings of Dog Row and Globe Road are effected by cast iron girder-bridges of great strength.

The London station, which forms part of the viaduct, is approached by a sloped road for carriages, and by staircases for foot-passengers; it extends from behind the houses in Shoreditch as far as Wheeler Street. There are four lines of way at this station, each terminating on a turning platform. The arches supporting the station are large circular segments. From the west side of Wheeler Street to the east side of Farthing Street, the viaduct is about 60 feet in width, and consists of seven semi-elliptical arches, each of seven rings, or 2 feet 7 inches in thickness. From the east side of Farthing Street to some way beyond Brick Lane, the viaduct is built to a width of about 52 feet; and thence to its termination at the temporary Mile End station it is 30 feet in width. The arches are generally semi-elliptical, of about 33 to 36 feet span, with a versed sine of about 9 feet 6 inches. They are constructed of seven rings, built in cement, the thickness being 2 feet $7\frac{1}{2}$ inches. The piers are seven bricks, or 5 feet 3 inches in thickness. The impost is of stone, 9 inches thick. At 18 inches above the top line of arches, a 9-inch stone-string runs the whole length. Each parapet is $1\frac{1}{2}$ bricks in thickness, and 3 feet 6 inches in height, including the bevelled coping, which projects over the brickwork $1\frac{1}{2}$ inches on each side. Each arch is backed with solid brickwork, which steps down regularly from 18 inches to about 3 feet 7 inches below the crown-line of arches, to the

middle of the pier, through a proper outlet in which the surface-water runs off into the drains below. Above the backing, and to the formation-level, the space is filled up with gravel ballast.

The bridge over Dog Row, which is on the oblique principle, the skew-span being 55 feet, is constructed of cast-iron longitudinal and transverse girders. The two longitudinal girders are each 3 feet in depth and 2 inches in thickness, with an upper and lower web each 9 inches wide, and run from one abutment to the other; these girders rest on plates 3 feet in width, having an impost moulding-cast in front, 12 inches wide, and covering the upper part of the brickwork. Between these are fixed thirteen cross girders at intervals of five feet, the whole being firmly bolted together, and secured by 3-inch cast iron ties running from each angle to the middle of the opposite longitudinal girder, each tie passing through perforations made in the cross girders, and keyed at each meeting. The parapets are also of cast iron, resting on the longitudinal girders, and have a neat appearance externally, being finished with a Gothic pattern. The castings were furnished by Messrs. Mather, Dixon, and Co., of Liverpool.

GAUGE OF WAY, &c.—For the purpose of getting more space than is usually allowed for the working parts of the locomotive engine, the engineer decided on deviating from the national gauge of way, and adopting one of increased width. Although this increase of a few inches entails but comparatively little expense in the construction of the works, and of the engines and carriages, yet it effectually prevents a junction with any line having the English gauge. Already we foresee that this difficulty will exist in connecting the Northern and Eastern Railway, which is at present but a branch of the Eastern Counties line, with the railways in the north.

The gauge of way is 5 feet, the intermediate space 6 feet 5 inches, and each side-space 6 feet 9½ inches wide; the top width of embankments being 30 feet.

The rails are of the double parallel form (see Plate III. fig. 106), and weigh 75 lbs. to the yard. They are secured to chairs of simple form with wooden keys; the chairs being spiked to cross sleepers of large size. The ballasting is of gravel throughout. The fencing consists chiefly of posts and three rails; in some parts, however, we observe that four, and even five rails

have been found necessary adjoining grass fields. As yet there are no distance-standards fixed up, without which no railway can be said to be complete.

The intermediate stations of Stratford and Ilford are on an extensive scale, and present a neat appearance; but we should gladly have seen less costly buildings at these places. At the stations of Brentwood, Romford, and Devonshire Street, Mile End, the buildings are, at present, but of a temporary character.

CARRIAGES.—The stock of carriages belonging to this Company is fully equal to any amount of passenger-traffic that may be expected until the line is opened beyond the present terminus at Brentwood. The carriages are altogether of handsome exterior, and are painted blue, with the arms of the Company emblazoned on either side.

The first-class carriages are in three compartments, each calculated to hold six persons, and fitted up in the usual way, with elbows, linings, and cushions.

There are a few mixed carriages, with two second-class compartments, each to hold ten, and a first-class compartment in the middle to hold six persons.

The second-class carriages, which are also in three compartments, will hold thirty passengers. They are open at the upper part of sides, but closed at top and ends. The length of these carriages is 14 feet 3 inches, the width 6 feet 7 inches, and the height 5 feet 9 inches.

The third-class carriages consist simply of truck-platforms, with eight open seats fixed thereon transversely, each of which will hold five persons, or forty altogether. By this arrangement the profitable weight is considerably increased, although not to so great an extent as in the *Stanhopes*, which are, however, much more fitted for dumb animals than rational beings.

The ordinary trains on this railway consist of one first-class, two second-class, and two third-class carriages, affording accommodation for 158 passengers. The number of trains daily at the present time, in each direction, is eleven. The time occupied by the trains which run from London to Brentwood without stopping, is about 36 minutes; and by those which stop at the intermediate stations of Mile End, Stratford, Ilford, and Romford,

about 47 minutes, the stoppages occupying about 6·40 minutes. Thus nearly five minutes is absorbed by the decreased speed about the intermediate stations. The distance between London and Brentwood is about 18 miles; the rate of travelling, therefore, by the through-trains is 28·33 miles per hour, and by the stopping-trains 21·70 miles including stoppages, or 25·12 miles per hour excluding stoppages.

LOCOMOTIVE ENGINES. — The locomotive engines used on this line are all from the works of Messrs. Braithwaite, Milner, and Co., of the New Road. In principle they much resemble Mr. Bury's engines; but there is an appearance of much greater weight and solidity in those of Messrs. Braithwaite. We have had no means of sufficiently testing the capability of the Eastern Counties engines; but of Mr. Bury's we have reason to speak highly with regard to their every-day work on the London and Birmingham Railway.

There are fourteen engines belonging to the Eastern Counties Railway Company, four of which have 12-inch cylinders, 18-inch stroke, two driving-wheels of 6 feet, and two bearing-wheels of 4 feet 6 inches diameter; 84 tubes of $1\frac{1}{2}$ inches diameter, and 8·89 feet in length; fire-box, $36\frac{1}{2}$ inches long, 37 inches wide, and $54\frac{1}{2}$ inches high; the surface of radiating heat being 62·16, and of communicative heat 365·90 superficial feet; boiler, 8·39 feet long, and 39 inches diameter; sectional area of steam-passage 8·70, and of blast-pipe 5 square inches; chimney, 13 inches diameter, and 6 feet high above smoke-box.

Then there are eight engines having 13-inch cylinders, 18-inch stroke, with wheels as above; 94 tubes of $1\frac{1}{2}$ inches diameter, and 8·89 feet long; fire-box, $36\frac{1}{2}$ inches long, 37 inches wide, and 56 inches high, the surface exposed to radiating caloric being 64·47, and of communicative heat 409·46 superficial feet; boiler, 8·39 feet long, and 42 inches diameter; steam-passage, 8·70 square inches; and blast-pipe, 6 square inches; the chimney being 6 feet high, and 14 inches diameter.

Besides the above, there are two luggage-engines, having 14-inch cylinders, 18-inch stroke, four coupled wheels, each of 5 feet diameter; 101 tubes, $1\frac{1}{2}$ inches diameter, and 9·04 feet long; fire-box, 41 inches long, 39 inches wide, and 56 inches high; the surface of communicative heat being 447·32 square feet, and of radiant heat 70·34 square feet; boiler, 8·51 feet long, and

44 inches diameter ; steam-passage, 10 square inches ; and blast-pipe, 7 square inches ; the chimney being 6 feet high, and 15 inches in diameter. These engines cost each 1300*l.*, exclusive of tenders.

The following statement shews the various items of expenditure up to 4th July, 1840 :—

Expenses incurred previous to, and in obtaining the Act of incorporation	£39,907	4	5
Parliamentary expenses	285	11	8
Lands and compensation	525,526	15	1
Surveyors, valuing lands, &c.	5,765	13	7
Works contracted for, including viaduct, bridges, stations, earthworks, &c.	362,736	15	7
Rails, chairs, sleepers, switches, spikes, screws, coke, cartage, wharfage, labour, &c.	203,373	10	6
Engineering	22,896	15	0
Law expenses for general business	4,576	2	3
Officers' salaries	6,806	15	1
Direction	8,824	8	6
Office-expenses, rents, rates, taxes, furniture, and Liverpool office	7,879	5	3
Advertising, printing, stationery, &c.	3,522	12	4
Travelling expenses, taking traffic, &c.	2,956	6	11
Accountant	625	0	3
Stamps for debentures, &c.	276	5	10
Locomotive engines, carriages, wagons, trucks, horse-boxes, water-cranes, &c.	38,998	19	10
	<u>£1,234,958</u>	<u>2</u>	<u>1</u>

In February of the present year, Mr. Robert Stephenson, having been requested by the Directors to examine Mr. Braithwaite's estimate for completing the line from the London terminus to Colchester, reported to the Board that he had gone through the prices, and had taken Mr. Braithwaite's statement of quantities as correct ; and that, with the exception of the want of a sum being allowed for ballasting, another sum for interest, and a third for the carrying-establishment, he considered Mr. Braithwaite's estimate would be found sufficient.

The following subdivisions of the estimate will be found useful :—

Land already purchased	£650,000	0	0
Expenses incurred in obtaining the Act of Parliament, and in the construction of those parts of the line under contract	678,971	0	0
Stations, engine-houses, and coke-ovens	83,000	0	0
Amounts for which contracts were let and tendered, with an addition of 10 per cent for contingencies	361,467	0	0
Estimate of line from Chelmsford to Colchester	306,737	7	7
Contingencies	56,967	12	11
Total estimated cost of line from London to Colchester	<u>£2,137,143</u>	<u>0</u>	<u>6</u>

This amount is only about 4000*l.* more than the joint-stock capital and loan together, as authorised to be raised by the first Act for constructing the whole line from London to Norwich and Yarmouth.

EDINBURGH AND DALKEITH RAILWAY.

THERE are at present but comparatively few passenger-railways worked by horses : of this number, however, the Edinburgh and Dalkeith is one of the longest in the kingdom, and is a fair sample of the very slight improvement in travelling, either as regards comfort or expedition, which, to this day, would have been effected without the aid of the locomotive engine. Few persons, we think, would prefer a railway-carriage drawn by one or two horses to a well-appointed four-horse coach, unless a considerable increase of speed should be obtained by the former. In practice this is not found to be the case ; and therefore, but for the powerful moter already alluded to, railways would, in all probability, have been entirely confined to the mineral districts.

The Edinburgh and Dalkeith Railway Company have constructed their works under the authority of three Acts of Parliament, dated respectively the 26th May, 1826, the 4th June, 1829, and the 27th June, 1834 : by these

Acts the Company were empowered to raise in joint stock the following sums, viz. by the first 70,125*l.*, by the second 8,053*l.*, and by the third 54,875*l.*, making a total of 133,053*l.*

The main line was first opened for traffic in July 1831; a second portion was opened in October of the same year; and the Leith Branch was partially opened in March 1835, and the remainder in July 1838.

INCLINATIONS AND CURVES. — The main line, which runs from the Edinburgh station to South Eske, is level for about half its length; and the remainder has an inclination of 1 in 234, the whole distance being $8\frac{1}{4}$ miles; the curved portions are set out with radii of from 600 to 1200 feet.

The Leith Branch is level for about one-third of its length; and the remaining portions have inclinations of 1 in 300 and 1 in 69 respectively, the whole length being 4 miles. This branch, at the Leith end, is laid out with a parabolic curve, beginning with a radius of 3600 feet, and terminating with a radius of about 1200 feet.

The Musselburgh Branch is altogether on an inclination of 1 in $51\frac{1}{4}$.

EARTHWORKS, BRIDGES, &c. — Clay and sand are the prevailing strata intersected by the cuttings of this line; the earthworks are not, however, peculiarly heavy. In the main line we counted seven bridges over the railway, four bridges under, six level road-crossings, which are of less consequence on a horse-line, eight sidings, and fifteen traverses, the main line being double throughout.

On the Leith Branch, the bridges are two over and one under the railway; there are also two level road-crossings and three traverses. According to Mr. Rankin, there are altogether ten level turnpike-road crossings. The bridges are all of stone, and of 24-feet span where over the railway.

There is one tunnel 572 yards in length, which is on the Edinburgh inclined plane; it has a semicircular stone arch, of 20-feet span, and is stated to have cost 20*l.* per lineal yard. The tunnel is lighted by twenty-five gas lamps. The cost of lighting the tunnel, workshops, and station, at Edinburgh, is about 22*l.* per annum.

GAUGE OF WAY, RAILS, &c. — The gauge is 4 feet 6 inches, and the inter-

mediate space 4 feet 10 inches, and each side-space 5 feet 1 inch, the top width of embankments being 24 feet: the whole width of land on a level is 30 feet.

The rails are of the fish-bellied form, in 15-foot lengths, weighing 28 lbs. to the yard; they were chiefly supplied from the Bedlington Works, near Tynemouth, at from 8*l.* to 14*l.* a ton. The rails are set in chairs placed at intervals of 3 feet, being secured thereto with iron keys. The chairs were cast in Edinburgh, and cost from 6*l.* 15*s.* to 10*l.* a ton. The whole way is laid with freestone blocks, measuring 24 inches by 18 inches, and 8 inches thick; the cost of each, delivered on the line, being 1*s.* 6*d.*

The ballasting is of broken whinstone, and costs about 3*s.* per cubic yard.

The number of men to keep way in repair is at the rate of about three for each two miles; and the annual cost per mile is 59*l.*

The fencing consists partly of stone walls, and partly of quick hedges.

STATIONS AND DEPÔTS. — The Edinburgh station and depôt occupies about eight imperial acres. There is nothing worthy of notice in the buildings at this station. The South Eske station-house is built in the cottage-style, and is of neat design. Besides the rooms occupied by the station-keeper, there is a general waiting-room, and one especially for ladies. There is a detached stable for eight horses. Near this station is a long wooden bridge, which carries the Marquess of Lothian's railway over the river Eske.

Besides the terminal stations, there is a half-way stopping-place, which is at the divergence of the Leith Branch. It is to be observed, that the driver stops to take up or set down a passenger whenever required. At Leith there is merely a shed-building. Contiguous to this station, the coal-owners have large enclosed yards, connected by sidings or small branches with the main line.

There is one book-keeper and one clerk in the manager's office; five collectors, one assistant, and three porters. The trains-guards are also constables, which arrangement is both economical and at times convenient. Each guard carries a bugle-horn, which he sounds lustily as occasion requires.

CARRYING DEPARTMENT. — The Company's stock of carriages at present consists of thirty-four passenger-carriages, eight luggage-vans, twenty goods-trucks, and eighty coal-wagons.

The passenger-carriages are of two kinds, closed and open; the closed carriages are in three compartments, each holding eight passengers. There are three doors only, which are on one side, the other side being entirely shut up; instead of side-lights there are blinds on each side of the glass sashes: there is a seat in front, and one behind, each of which will hold four persons, including the driver. There is a curved splash-guard in front of each outside seat; but we found they did not prevent the mud from being cast over in abundance, to the annoyance of ourselves and fellow-passengers. The carriage-body is 13 feet long by 6 feet $1\frac{1}{2}$ inches wide, and 4 feet 4 inches high; the extreme length is 19 feet. The wheels are of cast iron, 2 feet 8 inches diameter, the axles being of octagonal form, $3\frac{1}{2}$ inches diameter, and the journals 2 inches diameter, and $5\frac{1}{2}$ inches long. The springs are 3 feet 3 inches long, and 3 inches thick in middle; the under side of sole is 2 feet $3\frac{1}{2}$ inches above the level of the rails. The weight of a closed carriage (No. 5) is 59 cwt.

The open carriages have no roofs, and are divided into two whole and two half compartments, the whole compartments each holding eight, and the half compartments four passengers each: a splash-guard is fixed at each end, as in the closed carriages. The under frame is similar to that of a closed carriage.

The closed carriages cost 170*l.* each. The whole of the carriages are built by the Company.

The luggage-vans are 15 feet in length by 6 feet 4 inches wide; the wheels are $2\frac{1}{2}$ feet in diameter; the total weight about 32 cwt., and the cost 40*l.*

The goods-trucks have similar wheels to the above; the total weight is 30 cwt., and the cost 20*l.*

The coal-wagons weigh each about 22 cwt.; the cost is from 15*l.* to 17*l.*, the wheels being the same as for the goods-trucks.

There are eight trains leaving and eight trains arriving daily at the Edinburgh station. A passenger-train consists usually of three carriages, which are drawn from the station to the top of the Edinburgh incline by horses, and

also from the bottom of the incline the rest of the journey. Ascending the Leith Branch, two horses are required to one carriage; a boy rides on the leader, which is occasionally tripped up, and the boy is subject to sad accidents.

In this service, there are two guards on the main line, and one on the Leith Branch, the wages of each per week being about 15*s.*; eleven drivers, each earning about 12*s.* a week; and three switch-boys. In the summer there are about forty, and in the winter about twenty-five horses in use. Three horses are required for tracking at the Edinburgh station.

The cost of keeping horses is stated to amount to 25*l.* per annum for each horse. The usual load for a horse is four laden wagons in one direction, amounting to 14 tons 8 cwt. gross; or the same number empty in the other direction, amounting to 4 tons 8 cwt.; the distance for each horse, with one carriage daily, is twelve miles, the speed averaging about eight miles per hour.

If a passenger-train overtakes a train of loaded coal-wagons, the former passes by the first siding or traverse it comes to; but if the wagons are empty, the carriage-train keeps to the main line.

In the years 1838 and 1839, the number of passengers travelling on this line amounted to 548,164, and the receipts on this account to 13,672*l.* 15*s.*, which is at the rate respectively of about 876 passengers, and 21*l.* 16*s.* 9*d.* per diem. The proportion of third to first-class passengers is about 58 to 1; of third to second about 4½ to 1; and of second to first about 13 to 1. The duty paid to Government, according to Mr. Rankine, amounts to about 900*l.* per annum.

The traffic in coals, &c. is about 120,000 tons per annum.

STATIONARY ENGINE.—The inclined plane near the station at Edinburgh has an inclination of 1 in 30; it is 1160 yards in length, the upper part being straight, and the lower part considerably curved. It is worked by two low-pressure condensing engines, with cylinders of 28 inches diameter, stroke 6½ feet; average working-pressure, 5 lbs.; number of strokes per minute 19; fly-wheel, 12 feet diameter, and of 3½ tons weight; fly-wheel shaft, 10 inches square; rope-roll, 11 feet diameter, and 3 feet clear width; two five-inch ropes, each weighing 37 cwt.; sheeves, 14 inches diameter, and 8 yards apart; consumption of fuel, 2½ tons per diem, averaging about 4*s.* a ton,

being refuse from Sir John Hope's colliery. About 30 tons gross is the usual load drawn up, and five minutes the time occupied; the descending loads draw out the rope after them. The duration of ropes, Mr. Rankine considers, may be taken at $3\frac{1}{2}$ years: the cost is 36*l.* per ton. From 130 to 190 wagons of coal are drawn up daily, the quantity of coal in each wagon being $2\frac{1}{2}$ tons, and gross weight of each wagon 3 tons 12 cwt.; besides three passenger-carriages, together equal to 7 tons 6 cwt., which make eight trips daily. The average gross loads drawn up daily will thus amount to about 636 tons.*

The signals from the bottom of the incline are given by an air-tube, about $\frac{3}{4}$ inch diameter, with a small bell in engine-house, which was introduced on this line at the opening in July 1831.

These engines were erected by Carmichael, of Dundee, and cost 1000*l.* each, including boiler.

In connexion with this incline may be mentioned an ingenious plan for stopping the trains in case of the rope breaking. Mr. Rankine calls it a self-acting stopper. It consists of two plates of iron, each having a double claw, the points of which are 15 inches asunder. These plates are each $13\frac{1}{2}$ inches in extreme length, 9 inches along the middle line of each, and 6 inches wide in the middle, increasing to 15 inches at the points of the double claw. The plates are $\frac{1}{2}$ of an inch thick, and $5\frac{1}{2}$ inches apart, secured together with $1\frac{1}{2}$ inches bolts. At the narrow end is a roller, 2 inches in diameter; in the middle is a 2-inch axle, to which an arm or lever is attached, this lever being

* The persons employed in connexion with the incline are—

One engine-man, at per week	£1 10 0
Stoker, with rooms, and an allowance of coal	0 17 0
Two bank-riders, each 15 <i>s.</i>	1 10 0
And one man at bottom of incline	0 16 0
	<hr/>
	£4 13 0

The annual expense of working the incline will be—

Wages, as above	£241 16 0
Coals	156 10 0
Repairs of engines and ropes	133 0 $3\frac{1}{4}$
	<hr/>
	£531 6 $3\frac{1}{4}$

connected at its upper end with the last wagon of the train. By means of the roller the stopper runs on one of the rails; and the lever, by which it is connected with the wagon, keeps the stopper at uniform distance from the train while in motion; but in case of the rope breaking, the train immediately runs back, raises the arm, and thus throws the stopper over, which causes the train to run off the rails.

The expenses for three years ending the 31st December, 1839, were as follows :—

Way-leaves	£2,466	18	8½
Repairs of railway and works	1,576	1	11½
Materials and tools	1,716	9	9½
Wages and salaries	1,907	19	1
Station-keepers' wages	649	16	0
Horsing coaches	6,915	14	2½
Hire of coaches	199	5	2½
Maintenance of coaches	1,118	6	7½
Loss on omnibus account	85	14	0
Tracking at Edinburgh depôt	596	18	3
Taxes on passengers, coaches, and guards	1,692	12	2
Delivering parcels, &c.	69	3	9½
Trackage of goods, and loading	395	18	0½
Maintenance of wagons	245	14	4½
Sacks, covers, &c.	201	19	11½
Coals	464	18	6
Drawback on coal-dross, &c.	552	18	6
Gas, water, gas in tunnel, &c.	243	15	11
Candles, oil, hand-bills, cleansing	265	2	5
Repairs of fixed-engines and ropes	399	0	11½
Wages of engine and inclined-plane-men	893	11	2½
Weigher, constables, gas, public burdens, feu-dues, adver- tising, and printing, &c.	1,290	7	0½
Collector, policeman, hand-bills, and sundries	208	13	9½
Rent of depôt-ground, house, and office	63	3	0
Committee expenses	235	16	0
Law expenses	242	18	4
Interest on bank account	3,360	18	7½
Ditto on price of land	1,709	18	1½
	<u>£29,769</u>	<u>14</u>	<u>7</u>

The revenue for three years ending the 31st December, 1839, includes the following items :—

Tolls on goods not conveyed by Company	£13,199	13	1½
Use of fixed engines	2,595	12	6½
Conveyance of passengers	22,294	11	1½
Conveyance of goods	1,111	14	4½
Ditto of parcels	106	7	7½
Rents of ground and offices, discounts	1,752	7	9½
Old materials	117	13	3½
	£41,177	19	9½

Thus the profit for the three years as above amounts to 11,408*l.* 5*s.* 2½*d.*, or on an average to 3,802*l.* 15*s.* 4*d.* per annum; and the outgoings, including maintenance of way, repairs, &c., and current expenses, amount to 29,769*l.* 14*s.* 7*d.*, or 9,923*l.* 4*s.* 10½*d.* per annum, being about 72 per cent on the gross revenue.

EDINBURGH AND GLASGOW RAILWAY.

THE people of North Britain are proverbially cautious, but they are also sagacious and persevering. A long time elapsed before they would venture on so large a project as a grand trunk railway; but having carefully watched the movements of their brethren of the south in respect to these vast national undertakings, and being satisfied with the important results likely to accrue from their general introduction into Scotland, they have commenced operations in earnest, and already one important railway—the Ayrshire line—is in a state of active operation, while two others are in the course of rapid execution. Of the two latter, the Edinburgh and Glasgow is by far the most important line that can be formed in Scotland, connecting as it will, by an hour and a half's ride, the far-famed Edinburgh—the “modern Athens”—with the great commercial city of Glasgow. Who can foresee, we say, the great, the wonderful revolution that will take place in the affairs of Scotland by the opening of this important line?

Owing to severe opposition, it was not until the session of 1838 that the Edinburgh and Glasgow Railway Company were enabled to obtain an Act of Parliament; however, on the 4th of July of that year, their act of incorporation received the royal assent, and they have lost no time in prosecuting the works most vigorously. Their joint-stock capital is 900,000*l.*, and they have power to raise by loan 300,000*l.* additional. An amended act has been obtained during the session of 1840, which received the royal assent on the 23d July. We trust the parliamentary estimate is not like some of those for several lines both in England and Scotland, in which were *left out* the important items of *stations, locomotive engines, and carriages*. As well might a man build a house, and, when finished, find that he had not the means withal to furnish it.

COURSE OF THE RAILWAY.—Leaving the eastern terminus by the Haymarket at Edinburgh, the general course of the line is nearly west as far as Falkirk, from whence it pursues a direction about south-west to Glasgow. In its route it passes near to Kirkliston, Linlithgow, and Falkirk; and runs nearly parallel with, and on the north of the Edinburgh and Glasgow Union Canal, which it crosses near Lock Sixteen of the Forth and Clyde Canal; from whence it is nearly parallel, and on the south of this canal, all the way to Glasgow. Within about $3\frac{1}{2}$ miles of the Glasgow terminus, it crosses over the Monkland and Kirkintilloch Railway.

The worst curve in the line is at Springvale, north of Glasgow, being of about half a mile radius. The radius of curvature is generally about a mile.

The following table shews the inclinations of this line, commencing at Edinburgh:—

Lengths of Planes.		Ratio of Inclination.		Locations.
Miles.	Chains.			
2	70·00	ascending at the rate of 1 in 5280		Road by Broomhouse.
6	00·00	ascending „ 1 in 880		
	41·81	ascending „ 1 in 920		
3	40·00	ascending „ 1 in 880		Road by Philipstone.
5	00·00	descending „ 1 in 1056		Avon Water.
6	00·00	ascending „ 1 in 1056		Callander Wood.
	62·00	ascending „ 1 in 5456		
6	69·72	level.		

Lengths of Planes.		Ratio of Inclination.		Locations.
Miles.	Chains.			
2	27·87	. . . . .	ascending at the rate of 1 in 1200	Summit.
10	59·00	. . . . .	descending „ 1 in 1158·66	Cowlairs.
1	14·60	. . . . .	descending „ 1 in 43	
	15·00	. . . . .	level	Glasgow station.
<u>46</u>	<u>00·00</u>			

It will be observed by the above that, with the exception of the inclined plane at Edinburgh, the gradients throughout are all of the first class.

EARTHWORKS.—The amount of earthwork is considerable. The principal cutting is in Abercorn parish, which is about 50 feet in depth, nearly three miles in length, and amounting to a million of cubic yards. The slopes generally vary from $\frac{1}{2}$ to 1 to $1\frac{1}{2}$ to 1 in cuttings, according to the strata; and the embankments have slopes of from $1\frac{1}{2}$ to 1 to 2 to 1. The width of cuttings from side-drain to side-drain is 30 feet; and the top width of embankments 33 feet.

TUNNELS.—There are altogether five tunnels, amounting in length to 2200 yards. The first is at Winchburgh, and is 330 yards long; the second at Callander, 830 yards in length; and the remaining three, which are at the Glasgow inclined plane, are respectively 476, 292, and 272 yards in length; the span of each is 26 feet, and the height 22 feet. These tunnels are built of stone and brick, but chiefly of brick. The arches are 18 inches, and the side-walls 21 inches in thickness: except the Callander tunnel, which is in a curve of a mile radius, the whole are in straight lines.

BRIDGES AND VIADUCTS.—The bridges over the railway are generally of semi-elliptical form, and of 28-feet span; the versed sine being 5 feet, and the clear height 17 feet. There are thirty-one turnpike and high-road bridges under the railway, and thirty-three over. The principal skew bridge is over the turnpike-road at Linlithgow, which is built at an angle of 32° . The turnpike-road bridges under the railway are of 20-feet, and the highway-bridges 15-feet span respectively.

There are several viaducts of considerable extent; the principal of which

are over the Almond and Avon waters. The Almond viaduct, which is built of stone, is by far the most extensive work of the kind on the whole line, and consists of thirty-six segmental arches, each of 75 feet span, the versed sine being 16 feet 6 inches. The piers are each 7 feet in thickness. The clear width of railway between parapets is 26 feet. The whole length of viaduct is 720 yards, the extreme width 28 feet 4 inches, and the general height about 50 feet. The viaduct over the Avon valley consists of twenty, and the Redburn viaduct of eight arches respectively.

GAUGE OF WAY, &c. — The gauge is 4 feet 8½ inches; the rails are of the double parallel form, weighing 75 lbs. to the yard. Basalt or whinstone blocks are for the most part used; but occasionally larch sleepers, 9 feet long, 10 inches broad, and 4½ inches thick, being half logs. The ballasting is 28 feet in width, about 22 inches in thickness, and of various descriptions. The fencing consists chiefly of dry stone walls.

The following expenses were incurred from the 4th November, 1835, up to the date of obtaining the Act of incorporation, on the 4th July, 1838 :—

Solicitors and parliamentary agents' charges	£27,801 16 1
Engineering and surveying	10,290 7 1
Deputations to London, witnesses, and other incidental charges	10,219 14 9
Salaries of secretaries and clerks	3,872 18 10
Advertising, printing, and engraving	1,188 5 9
Postage, parcels, and stationery	215 18 2
	<u>£53,589 0 8</u>

Thus the expenses up to the time of obtaining the act of incorporation amounted to about 1,165*l.* per mile of railway.

The following statement shews the different items of expenditure from 4th November, 1835, to 30th June, 1840 :—

Works	£236,658 16 5
Land and compensation	103,622 3 8
Solicitors and parliamentary agents	31,803 18 2
New act	692 0 0
Engineering and surveying	17,246 17 1

Deputations to London, &c.	£ 10,558	4	4
Salaries	6,308	8	9
Advertising, printing, &c., postage, parcels, &c.	5,075	18	7
House in Queen Street, Glasgow	2,000	0	0
Direction for twenty-one months	1,750	0	0
Counting-house furniture	485	15	5
Police, as required by act	830	19	2
Sundries	1,326	3	3
	<u>£ 418,359</u>	<u>4</u>	<u>10</u>

The works of this railway have been carried into execution under the general direction of Mr. Miller, of Edinburgh, and are expected to be completed in 1841. The principal contracts are let to Messrs. Gibb and Son, Messrs. Forbes, Ross, and Mitchell, and Mr. Marshall.

EDINBURGH AND NEWHAVEN RAILWAY.

EDINBURGH has been rightly called the “modern Athens;” the magnificence of its streets and squares, and the chaste style of architecture adopted almost throughout the length and breadth of the new town, fully entitle it to this appellation. Edinburgh, however, as every other city or town, would become as nothing without the improved mode of communication by railway, which annihilates, as it were, both time and space.

Already an important line of railway is in a state of great forwardness—we allude to that between Edinburgh and Glasgow—and so far back as August 13, 1836, the royal assent was given to an Act for making a railway from Edinburgh to Newhaven, with a branch to Leith. The branch has, however, been abandoned by the amended Act, obtained in the session of 1839; and the main line to Newhaven is at present but in a very unfinished state; indeed, the tunnel at Edinburgh is not yet commenced.

The Act obtained in 1836 enabled the Company to raise a capital in joint

stock of 100,000*l.*, and an additional sum by loan of 40,000*l.* An amended Act was obtained in the session of 1839.

Messrs. Grainger and Miller originally laid out this railway ; afterwards it was under the direction of the late Mr. H. H. Price ; but it is now in the hands of Mr. M'Neil, who will no doubt do all in his power to bring it to a speedy completion.

The direction of this line is north-east from the proposed western terminus, which is a little to the west of the North Bridge by the City Weigh-house ; indeed, it is in the same place as that originally proposed for the eastern terminus of the Edinburgh and Glasgow Railway. It is very desirable that these two lines should be brought to this point, as there would then be a complete railway communication between the two seas. The line is straight to the Trinity Chain-pier at Newhaven, except for about a quarter of a mile near Cannon Mills, where there are curves of a mile radius. It is intended to pass by a tunnel under Princes Street transversely, and longitudinally under St. Andrew's Street, the east side of St. Andrew's Square, Duke Street, Dublin Street, and Scotland Street, near the bottom of which is the proposed northern entrance to the tunnel. It thence proceeds on embankment across the water of Leith, and by cutting under Queensferry Road, thence to its termination at the Trinity Suspension Pier.

The whole length of this line is 2 miles 8 chains. The first plane from Edinburgh, which is through the tunnel, descends at the rate of 1 in 27·45 : this will of course be worked by a stationary engine. The next is a level plane for 10·40 chains ; then succeeds an ascending plane of 1 in 160 ; and lastly, the Newhaven terminal plane descends at the rate of 1 in 360. It will be seen that the gradients are not of the first class. The total width of land, taken on a level, is 48 feet, including six feet on each side for hedge and ditch ; and where between retaining walls, the clear width is 30 feet.

For the short length of this line, the earthworks are heavy. The chief is the Queensferry Road cutting, containing 200,000 cubic yards ; the greatest depth being 33 feet. When we visited these works in the autumn of 1839, this cutting was completed from the Water of Leith embankment to the Queensferry Road Bridge ; part of the produce of which, to the amount of 88,000 yards, is carried to spoil, and the remainder to the embankments north and south of it. The slopes of cuttings and embankments throughout are

formed at $1\frac{1}{2}$ to 1. The total quantity of earthworks is stated to be 300,000 cubic yards, and the cost at 8*d.* per cubic yard.

The Edinburgh proposed tunnel is 1,001 yards in length, 24 feet wide, and 17 feet high; and is to be lighted throughout with gas. The open cutting at the north end of tunnel is 30 feet deep on an average. The strata, we are informed, consists of sand, shale, basalt, and freestone. The deepest vertical shaft for working the tunnel would be 90 feet.

There is a neat bridge carrying the Queensferry Road over the railway. It is built of Cragleith stone. The arch is semi-elliptical, and 32 feet in span, with a versed sine of 11 feet. At level of rails, the clear width between abutments is 30 feet; thus forming a 12-inch batter to the springing line. The width between parapets is 41 feet, including two footways; and the parapets each 18 inches in thickness. The whole cost 1,500*l.*, including the excavation.

Similar bridges are intended for Anchorfield Road and Lennox Road, both over the railway.

A wooden bridge, of three openings, is intended to carry the railway over the Water of Leith.

The ballasting is 22 inches thick, and consists of broken whinstone from the cuttings.

The fencing consists of posts and three rails, fixed outside the ditch.

Near the Newhaven Chain-pier the cutting is decreased in width full 48 feet, by the introduction of stone retaining walls; this was, no doubt, done on account of the increased value of land in this locality. The length of each retaining wall is 87 yards; its height above the rails is about 17 feet, and the average thickness 5 feet, with counterforts to strengthen them. The footing courses are five in number; these walls are built with a batter of $2\frac{1}{2}$ feet in the height, the radius of curvature being 60 feet. A 24-inch barrel-drain runs down under the centre line of this cutting throughout.

Account of payments up to 30th June, 1840.

Expenses up to 31st December, 1839 . . .	£ 28,349	9	0 $\frac{1}{4}$
Payments on account of additional act of parliament . . .	739	16	6
Purchase of property and compensation . . .	5,366	14	2
Works	1,390	6	8
Taxes, repairs, &c.	217	13	5 $\frac{1}{4}$

Balance of Mr. French's claims	£195 15 0
Allowance to bankers, &c.	156 5 0
Engineering	150 13 11
Direction	148 16 2½
Arbitrations, valuations, &c.	86 2 10
Law expenses	65 0 0
Advertisements, printing, &c.	47 14 2½
Secretary and clerk	100 0 0
Office rent	24 0 0
	<hr/>
	£ 37,038 7 0
	<hr/>

GARNKIRK AND GLASGOW RAILWAY.

Scotch folks, generally, are frugal almost to a fault; few, if any other kindred or nation of the earth can keep pace with them in works requiring more than ordinary perseverance, exertion, and self-denial. It is owing to this nationality of character that what in England is called poverty is comparatively unknown in North Britain. Look to whatever quarter of the globe you will, and you find the enterprising inhabitant of Scotland: he is pursuing his object with a steadiness of purpose and an extraordinary degree of untiring energy and perseverance, oftentimes undergoing what others would call the most severe privations; but his efforts are generally crowned with success; while others, similarly situated, and almost as persevering, yet wanting the peculiar characteristics of the Scotch character, frequently fail in all their attempts, and sink into distress and poverty.

We need, however, look no further than our own country to find ample illustrations of the above remarks. We were led into this train of thought by the observations we made on our railway tour of Scotland. We were particularly struck with a curious fact exhibited in the case of the Garnkirk and Glasgow Railway. This Company, in order to be on a par with the railway companies of England, had provided handsome and well-appointed carriages; but, whether the fares were slightly raised in consequence or not, the traffic fell off wonderfully; the new carriages were consigned to the soli-

tude of the shed; and the unsightly and uncomfortable old boxes were alone to be found on the railway.

This Company have obtained four Acts of Parliament, dated respectively the 26th May, 1826, the 14th June, 1827, the 7th June, 1830, and the 4th of July, 1838. By the first Act they were authorised to raise a capital in joint-stock of 28,497*l.*; by the second, 9,350*l.*; by the third, 21,150*l.* by loan; and by the last Act, 89,198*l.*, making altogether 148,195*l.*

COURSE OF THE RAILWAY. — Commencing at St. Rollox, near Glasgow, the line pursues a straight course to Milton; thence, curving across Robroyston Moss, and falling into an eastern course, passes by Clay House; and again curving into a direction about south-east, intersects another moss in Cadder parish, and proceeds to the south of Gartcosh, and near Whitehill; thence passing within a short distance of Gartcross, which is on the south, terminates by a junction with the Monkland and Kirkintilloch Railway, near Gargill Colliery, at Gartsherrie, the whole distance being eight miles. For the 5½ miles between the Robroyston Moss and the eastern terminus, the line is nearly level; and the remainder of the line has a descent to the Glasgow depôt.

The curves are of about a mile radius, except that near Gartcross, which is of about half a mile radius.

EARTHWORKS, BRIDGES, &c. — There are one or two heavy cuttings and embankments; but, for the most part, the earthworks are slight. There are altogether five bridges on the line, three of which carry roads over the railway; and six level crossings, at which points there are gates to close either the railway or the roads as required.

GAUGE OF WAY, RAILS, &c. — The gauge is that known as the Scotch gauge, of 4 feet 6 inches; the intermediate space is 4 feet 10 inches; and at Gartsherrie the side-spaces are each 8 feet wide.

The whole of the double way was originally laid with fish-bellied rails, 28 lbs. to the yard, in 15-foot lengths; the cost per ton being as much as 14*l.*

In 1839, an entire way had been reinstated with heavier rails of two descriptions, viz. 42 lbs. and 50 lbs. to the yard; those of 42 lbs. per yard

have $2\frac{1}{2}$ feet bearings, and the 50 lb. rails 3 feet bearings, the intermediate chairs for the latter weighing each 15 lbs., and the joint-chairs 18 lbs. Stone blocks are used throughout, except for about a mile over the moss-lands, where the rails are laid on longitudinal timbers of red pine, measuring 9 inches by $4\frac{1}{2}$ inches; or on cross sleepers of Scotch fir, $6\frac{1}{2}$ feet long, and placed at intervals of 3 feet. Small-coal ballast is used throughout. The quick hedges are in a thriving state. Stone walling is also used in parts, to fence off the railway from the contiguous lands.

DEPÔTS AND STATIONS. — At the St. Rollox depôt there are several lines of way; the buildings for the repairs of the locomotive engines, and for the carriages, &c., are here situate; and there is a small booking-office and passenger-hall, or what in England is better known as a waiting-room.

At Gartsherrie there is an inn, which also serves for the station-house. There are two or three intermediate stopping-places; but no buildings are required, as the intermediate traffic is but small.

CARRIAGE DEPARTMENT. — The Company's stock of carriages in 1839 consisted of eighteen closed and open, the average weight being about 35 cwt. The wheels are of cast iron, 2 feet 9 inches diameter, and weighing 12 cwt. per set. Three of the carriages will hold sixteen, and the rest twenty-four passengers each. The larger carriages are each $13\frac{1}{2}$ feet long, 6 feet wide, and 5 feet 2 inches high; the framing consists of American oak, and the panels of American pine. The smaller carriages are $12\frac{1}{2}$ feet long, 6 feet wide, and 5 feet 7 inches high; these latter have doors only on one side, on account of the prevailing north-wind; and the interior of each of the three compartments is lighted by a small glass sash on one side, and by a single small square of glass on the other. The cost of one of the last-described carriages is about 50*l*. In fine weather the sides of some of the carriages are taken off. These carriages are by far the most unsightly and uncomfortable we have met with on any passenger-railway in the United Kingdom.

There are about 270 wagons in use on this railway, which are lent by the Company for the use of traders, at 9*d*. a day, or 3*s*. a week each. These wagons have cast iron wheels, 2 feet 9 inches diameter. There are also eight trucks, with similar wheels: the cost of a truck is about 16*l*.

LOCOMOTIVE ENGINES.—In 1839 there were six locomotive engines belonging to this Company, the general proportions of which will be seen by reference to Table No. IV. in the Appendix. The wheels are of cast iron; the whole length of an engine is 15 feet 3 inches; the usual pressure of steam is 50 lbs. The fuel used consists entirely of coal, which, for the passenger-trains, is any thing but agreeable. Though rather unsightly, the engines are capable of drawing very heavy loads.

The tenders are built at the Company's Works at St. Rollox, and are six in number, each of which consists of a wagon, with soles, $10\frac{1}{2}$ inches deep by $3\frac{1}{2}$ inches wide, having upright sides, the length being 8 feet 3 inches, the width 6 feet, and the height 2 feet 1 inch. Each tender is mounted on four cast-iron wheels, of 2 feet 9 inches diameter: the weight, exclusive of fuel and water, is $2\frac{1}{2}$ tons; and the gross weight 4 tons 4 cwt. The quantity of water evaporated with the ordinary loads in a double trip of sixteen miles is about 400 gallons.

TRAINS, TRAFFIC, &c.—The passenger-trains usually consist of three carriages. The average speed we found to be about 16·41 miles per hour; and the stoppages to average each '65 minute.

The following abstract taken from the Company's printed Reports, and from the Parliamentary Reports of 1839 and 1840, exhibits the comparative state of the traffic* for eight years, ending 31st December, 1839:—

Year.	No. of Tons.	No. of Passengers.	Revenue.
1832	114,144	62,605	£ 6,476 6 5
1833	112,471	96,003	7,234 18 4
1834	132,657	117,743	8,413 11 3 $\frac{1}{2}$
1835	143,520	136,724	9,311 0 6
1836	137,867	145,703	10,324 0 4
1837	146,851	119,490	11,839 16 2
1838	181,615	128,378	13,643 14 2 $\frac{1}{2}$
1839	206,275	97,777	13,462 18 4 $\frac{1}{2}$

* A communication has lately been effected between Glasgow and Edinburgh by means of the Garnkirk, Monkland, Ballochney, and Slamannan Railways and the Union Canal, which will, in all probability, greatly increase the traffic on the Garnkirk line, until the opening of the Edinburgh and Glasgow Railway, which is expected to take place in 1841.

In the eight years, as above, the total number of tons conveyed on this line was 1,175,400; and the total number of passengers 904,423, the gross receipts for this period amounting to 80,706*l.* 5*s.* 5½*d.*, of which 54,953*l.* 12*s.* 5½*d.* was for goods, coals, &c. Thus the average number of tons conveyed per *lawful* day was at the rate of 469·40, and the average receipts on this account per diem 21*l.* 18*s.* 11*d.* The average number of passengers per *lawful* day for the same period was 361·19, and the average receipts per diem 10*l.* 5*s.* 8½*d.*, or 6·83*d.* per passenger.

The proportion of first to second-class passengers in 1839 was nearly as 14 to 1.

The gross receipts for 1839 amounted to 13,462*l.* 18*s.* 4½*d.*; the expenditure for the same period was 7,633*l.* 18*s.* ½*d.*, being 56·70 per cent on the revenue.

Messrs. Grainger and Miller, of Edinburgh, are the engineers by whom the Garnkirk Railway was laid out, and under whose direction the works were executed.

The cost of the railway works in 1834 was stated to be 98,519*l.* 9*d.*, and of locomotive engines, wagons, and carriages, 8,845*l.* 11*s.* 3*d.*; together 107,364*l.* 12*s.*, or at the rate of about 13,420*l.* per mile.

GLASGOW, PAISLEY, KILMARNOCK, AND AYR RAILWAY.

THAT two grand trunk-lines between England and Scotland will eventually be carried into execution,—the one from Newcastle to Edinburgh on the east, and the other from Lancaster to Kilmarnock on the west,—is the general opinion of those most conversant with railway matters. Glasgow being the commercial city of Scotland must, in a national point of view, be considered the more important of the two cities to be connected by railway in the first instance with the British metropolis.

Already the Western grand trunk extends from London to Lancaster; and the whole route forward from thence to the Ayrshire line, near Kilmar-

nock, has been examined as to different portions by engineers of long standing, and found to possess no more than ordinary difficulties. The Glasgow and Ayr Railway, or, as it is frequently called, the Ayrshire Railway, will thus for several miles form a link of the western chain of railway communication between London and Glasgow; and great will be the accession of traffic to this already steadily improving line, so soon as this desirable end is accomplished.

This Company's Act of incorporation received the royal assent on the same day as that of the Greenock line, which branches from it at Paisley. It is dated 15th July, 1837, and gave power to the Company to raise a capital in joint stock of 625,000*l.*, and an additional sum by loan of 208,300*l.*, making together 833,300*l.* An amended Act has since been obtained by this Company, which received the royal assent on June 4th, 1840.

COURSE OF THE RAILWAY. — Leaving the station at Tradeston, Glasgow, the line runs parallel for about a mile with the Glasgow and Paisley Canal; thence, in a straight line for about three miles, taking a western course as far as Laigh Hillington, and, with a curve of about two miles radius, continues on to Paisley; recurving at that place, and crossing the river Cart, it continues to the north of Elderslie, crossing the Glasgow, Paisley, and Johnston Canal, at three different places, and passes to the south of Johnston; thence, curving in a south-western direction, runs nearly parallel with the Black Cart river and Castle Semple Loch; proceeding thence in a straight course for two miles, it verges on Kilbirnie Loch, and keeps to the east of Garnock river, which it crosses at Carse Head, in Dalry parish. The line now pursues a course more nearly approaching south, passing Dalgarnvan Mill, and crossing the town of Kilwinning on the west side, near which the Ardrossan Railway diverges; from Kilwinning it is traced to Irvine; thence, nearing the Frith of Clyde, in Dundonald parish, to Barassie Mill, beyond which it crosses the Kilmarnock and Troon tramway, the property of the Duke of Portland; thence curving between Monkton and the Frith of Clyde, and passing close to Prestwick, continues in a straight line to its terminal station, near the new bridge at Ayr, and on the north side of the river.

The curvature is very favourable throughout, the worst curves having nearly a mile radius.

The proposed branch to Kilmarnock leaves the main line in Dalry parish, at about $22\frac{1}{2}$ miles from the south side of the Clyde at Glasgow; and, taking first a course a little to the east of south for about two miles, curves into a direction about south by west, which it pursues to its termination at Kilmarnock.

GRADIENTS.—The gradients are of the first class, twelve feet being the steepest rise per mile throughout the whole line; and this is only for six miles on the plane descending to Kilwinning. About one-fourth of the main line is level; and the other gradients are 8·80 feet, 5·28 feet, and 2·64 feet respectively, the length of main line being forty miles. The summit-level is at Kilbirnie Loch, 19 miles from Glasgow, the rise to which is only 70 feet.

The Kilmarnock Branch is 11 miles 8·40 chains in length, of which $8\frac{1}{2}$ miles ascends from the main line, with a six-feet gradient; and the remainder is level. Kilmarnock will thus be distant from the Glasgow station at Tradeston 33 miles 58 chains.

EARTHWORKS.—Among the principal earthworks may be mentioned the Ibrox cutting, which is about 90 chains in length, and on an average about 20 feet in depth; and also the Arklestone tunnel cuttings, together about 60 chains in length, and averaging about 30 feet in depth. These works are on that part of the line lying between Glasgow and Paisley. Between Paisley and Ayr the earthworks are comparatively slight.

BRIDGES, VIADUCTS, &c.—Between Irvine and Ayr, a distance of about $10\frac{1}{2}$ miles, which was the part of the railway finished when we viewed this line in 1839, we counted six bridges over, and six under the railway, seven level road-crossings, and twelve level field or occupation-crossings. The arches over the railway are chiefly of semi-elliptical form. Among the principal bridges may be mentioned those over the Irvine and Garnock waters, and that over the river Cart at Paisley; which latter is of one arch 85 feet in span, and has a bold appearance. At this place the streets are passed over by a viaduct, with arches of different sizes according to the width of the streets or roads crossed. There are seven streets and roads passed over by this viaduct. The principal work, however, in this depart-

ment is the Tradeston viaduct. The arches are generally of segmental form, of 18-feet span, with a versed sine of $6\frac{1}{2}$ feet. The arches are two bricks, or 18 inches, in thickness; and the piers 3 feet. The width of this viaduct is 50 feet; over some of the streets the viaduct is continued by iron girders. The materials of the arches generally consist of brick and stone. The bricks cost about 30*s.* a thousand; and the brickwork is executed complete for about 16*s.* per cubic yard. The freestone used in this structure is from Giffneck, near Pollockshaws, and is worth about 18*d.* per cubic foot wrought. The masons and bricklayers earn from 4*s.* to 4*s.* 6*d.* a day.

There is one short tunnel at Arklestone, 200 yards in length; the arch of which is of semicircular form, and is two bricks in thickness, the side-walls being $2\frac{1}{2}$ bricks thick. The level of the rails is about 50 feet below the surface of the ground above.

STATIONS.—Besides the terminal stations of Glasgow and Ayr, there are several intermediate stations, the principal of which are at Paisley, Johnston, Beith, Kilwinning, Irvine, Troon, and Prestwick.

The Ayr station is altogether well arranged, and the design of the buildings perfectly appropriate. The front of the offices, which is towards the river, extends 83 feet 4 inches, and the two end wings are 24 feet in depth. In the middle part of the building is the general booking-office, with two doors next to the passenger-shed, the one for first-class, the other for second-class passengers. On the right of the office is a ladies' waiting-room, and beyond it one for gentlemen, with suitable conveniences. On the left of the booking-office is another room for the goods-department. The passenger-shed is 159 feet in length; the platform, which returns at the end next the offices, is 13 feet wide, and about 2 feet from the outer rail. Along the platform is an iron railing, which separates the first-class from the second-class passengers in their progress to the carriages. There are two lines of way under the shed; and two additional lines in the goods-shed adjoining, which is 100 feet in length.

GAUGE, RAILS, &c.—The gauge of way is the same as the English standard, viz. 4 feet $8\frac{1}{2}$ inches; the intermediate space is 6 feet 5 inches, and each side-space 8 feet wide. The rails are of two kinds, viz. the double

parallel and the bridge sections (Plate III. figs. 12 and 13). The double parallel rails are in 16-foot lengths, and between Glasgow and Paisley are of 75 lbs. weight to the yard. They are fixed with 4-foot bearings in heavy chairs, and secured by wooden keys $6\frac{1}{2}$ inches long, and having a cross section of 3 inches by 2 inches. The chairs are 10 inches long and 5 inches wide. Both whinstone blocks and wooden sleepers are used on this line. The intermediate blocks contain each four, and the joint blocks five cubic feet; the intermediate blocks cost on the line about 3*s.* 9*d.* each. Felt is used as a medium between the chairs and blocks. The sleepers, which are of larch, are 9 feet long, and measure 9 inches by 5 inches, being half logs.

At Irvine part of the way is laid with continuous bearings, the rails being of the bridge-form, in 15-foot lengths, and weighing 45 lbs. to the yard. In 1838 these rails were supplied by Bailey, Brothers, and Co., at 11*l.* 7*s.* 6*d.* per ton. In the autumn of 1839 the price was 10*l.* 18*s.* per ton.

The longitudinal sleepers consist of Memel logs, unkyanized, 12 inches wide by 6 inches thick; these rest upon cross sleepers, 8 feet 6 inches long, the scantling being 6 by $3\frac{1}{2}$ inches. The longitudinal timbers are secured to the cross sleepers with screw-bolts and nuts; and the rails are attached to the longitudinal timbers with $\frac{1}{2}$ -inch screw-bolts, 10 $\frac{1}{2}$ inches long. The ledges of rails are perforated with holes for the screw-bolts; these holes are 18 inches asunder on alternate sides. The timbers are coated with tar. The longitudinal timbers are scarfed at the meetings, and bolted through to the cross sleepers.

The ballast consists partly of gravel, partly of broken stone, and partly of sand.

The fencing is of rough stone walling, and also of posts with three rails.

The mile-standards are of stone, and are placed at intervals of a quarter of a mile.

CARRIAGES AND ENGINES.—There are three classes of carriages, first, second, and third. The first and second-class carriages correspond very nearly with those in general use on the English railways. The first class are calculated to hold eighteen, and the second class each thirty passengers; the cost of the former being 400*l.*, and of the latter 120*l.* each. The third class

are Stanhopes, or stand-ups, somewhat similar to those on the Manchester and Leeds Railway.

The locomotive engines are of the same description as those used on the London and Birmingham line, with 12-inch cylinders, 18-inch stroke, and four wheels, the drivers being of 5 feet 6 inches, and the leaders of 4 feet diameter. The net weight is $8\frac{1}{2}$ tons, and with complement of fuel and water 10 tons. Four of them are called the Mazeppa, the Mercury, the Marmion, and the Cutty-sark. The cost of one of these engines, including tender, is stated to be 1,200*l*.

The average rate of travelling on that part of the railway lying between Irvine and Ayr, we found to be about 21 miles an hour; and the stoppages averaged about 1·06 minutes each.

The number of passengers who travelled on this line from 5th August, 1839, to 5th August, 1840, was 137,117, or on an average at the rate of about 438 per diem. The maximum fares which have been charged to each class of passengers is respectively 2*d*., 1½*d*., and 1*d*. per mile.

The following exhibits the various items of expenditure incurred on account of this undertaking up to 30th June, 1840:—

Expenses to 20th December, 1837	£21,166	3	5
Works	242,805	19	8½
Rails and chairs	97,392	0	10
Blocks	20,941	15	2
Iron-work and castings for bridges	7,067	1	0
Sleepers and wood-works	10,821	5	2
			<hr/>
	379,028	1	10½
Lands and compensations	107,411	2	6
Engines	8,830	15	8
Carriages	5,153	9	6
			<hr/>
	13,984	5	2
Engineering and surveying	6,891	12	0
Law expenses and agency	3,200	10	2½
			<hr/>
	10,092	2	2½
Direction	1,700	0	0
Salaries and police, including original secre-	1,139	4	11
tary's account			
Salaries of secretary and clerks	945	10	0
Police	834	10	6½
			<hr/>
	4,619	5	5½

Advertising, stationery, and printing . . .	1,251	0	11	
Office-expenses, furniture, stationery, and travelling expenses }	1,576	2	11½	
Charges	57	8	6	
Travelling expenses	70	11	7	
				2,955 3 11½
Interest, including debentures and stamps . . .	1,355	12	8½	
Loss on forfeited shares	410	3	1	
				1,765 15 9½
Renfrewshire Road trustees				6,000 0 0
				<u>£ 547,022 0 4½</u>

In the above account only half the cost of that part of the railway lying between Glasgow and Paisley is included, it having been executed by the Glasgow and Ayr and Glasgow and Greenock Railway Companies conjointly. If the other moiety of the cost of the joint line be added to the sum as above, the whole expense of the railway from Glasgow to Ayr, up to 30th June, 1840, will be 732,381*l.* 16*s.* 3*d.*

GLASGOW, PAISLEY, AND GREENOCK RAILWAY.

THE steam-boats of the river Clyde have long enjoyed a large share of patronage from the facilities they have afforded to the public of reaching quickly, and at a low rate of charge, the various towns and places along its banks. Between Glasgow and Greenock especially, the traffic has for many years been very considerable; but if we can judge by parallel cases in England, many of the steamers will surely be removed from this station on the entire opening of the Glasgow and Greenock Railway. We have witnessed the effect of such a change, particularly on the Tyne, where the steam-boats, although running at lower fares than those of the North Shields and Brandling Junction Railways, which are on either side of the river, are almost deserted. From what we have said, however, with regard to the Garnkirk and Glasgow Railway, the case may be somewhat different in Scotland.

This Company obtained their act of incorporation on the 15th July, 1837, and were empowered to raise a capital in joint stock of 400,000*l.*, and an additional sum by loan of 133,333*l.* They have since obtained an amended Act, which received the royal assent on the 23d July, 1840.

The joint railway between Glasgow and Paisley was opened to the public on the 13th July of the present year.

COURSE OF RAILWAY.—The Ayrshire Railway and the Greenock Railway proceed as one line from Glasgow to Paisley, just beyond which place they separate. From the point of divergence, which is about 6 miles 70 chains from Glasgow, the Greenock Railway, in a slightly curving line, passes close to the southern extremity of the race-course; thence by West Walkinshaw, across the Black Cart and Gryfe Waters, and in a straight line, intersecting Folwood and Dargavel Mosses, as far as Bishopton Ridge, where the line runs in a curve of about a mile radius; thence continuing to Laigh Hatton and West Ferry, beyond which it is carried close on the south bank of the Clyde; from whence it proceeds to Port Glasgow, and passes in a curvilinear course to its termination at Greenock. The curves are generally of about a mile radius, except in passing through Greenock, where the radius of curvature is about 45 chains.

The following table exhibits the length and inclination of each plane, commencing at Glasgow :—

Lengths of Planes.		Ratio of Inclination.	Locations.
Miles.	Chains.		
	57	level.	
1	42	descending at the rate of 1 in 2000	
2	75	ascending „ 1 in 1200	
1	47	level	Arklestone.
	11	descending „ 1 in 522	Paisley.
1	77	descending „ 1 in 398	
	15	level.	
3	67	ascending „ 1 in 330	Bishopton summit.
4	00	descending „ 1 in 330	
	74	level.	
1	52	ascending „ 1 in 437	Port Glasgow.
	42½	ascending „ 1 in 1397	
2	42½	level	Greenock.
22	42		

The branch to the docks at Port Glasgow descends at the rate of 1 in 45, and is about $18\frac{1}{2}$ chains in length; and the Greenock Dock Branch is about 20 chains in length, and descends at the rates respectively of 1 in 21, 1 in 34, and 1 in 400.

It will be seen by the above table, that although the gradients are not so excellent as those of the Ayrshire Railway, yet they all come within the first class. The summit of the line is at Bishopton, where the height above the rails at Glasgow is about 43 feet; and the difference of level between the Glasgow and Greenock termini is about eight inches. The summit, however, is about three miles nearer to Greenock than Glasgow.

By introducing second-class gradients on either side of the summit, a considerable saving of expense would have been effected in the Bishopton tunnel-cuttings, as well as in the tunnel-shafts.

EARTHWORKS.—In order to expedite the works between Paisley and Greenock, during the summer of 1840 about 3000 men, 200 horses, one locomotive, and three fixed engines, have been in constant operation. The Bishopton Ridge presents the greatest works in this department, consisting of cutting chiefly in rock on either side, and between the two tunnels. The want of vertical shafts has been materially felt, and the work in consequence much retarded. The cuttings at this place amount to about 85 chains in length, and average about 37 feet in depth; and at the tunnel-entrances the average depth is 70 feet. The other cuttings worthy of notice are the rock-cutting at Cartsburn Hill, which is about 25 chains in length, and 40 feet in depth; and the marl-cutting of Carnegie Hill, which is upwards of one-third of a mile in length, and 60 feet in depth.

The embankment leaving Paisley, and running across Fulwood Moss, is nearly four miles in length, but is rather shallow, not exceeding 10 feet in height on an average. The parts of the railway passing over Fulwood Moss and Dargavel Moss will, no doubt, for some time cause considerable expense in keeping the rails to the proper levels.

The woodside embankment by the Clyde is about 85 chains in length, and on an average about 28 feet in depth. The embankments towards Paisley are about 34 feet in width on a level with the rails.

BRIDGES AND VIADUCTS.—There are about sixty bridges and culverts between Glasgow and Greenock, including the Port Glasgow and Greenock viaducts. The masonry and brickwork which we had an opportunity of seeing appeared to be executed in a substantial manner. The viaducts of Glasgow and Paisley are on a larger scale, that of Glasgow being 50 feet wide. This latter work is described in the account of the Glasgow and Ayr Railway.

GAUGE OF WAY, RAILS, &c.—The English gauge is very properly adopted on this railway, as there will surely, ere long, be a direct communication from the metropolis to Glasgow. Had any other gauge been introduced, it would have caused considerable inconvenience, and quite prevented a connexion between the English railways and the Ayrshire and Greenock lines. The intermediate space is 6 feet $2\frac{1}{2}$ inches, and each side-space 9 feet 3 inches.

The rails are of the double parallel form (see Plate III. fig. 14), weighing 75 lbs. to the yard.

Both blocks and sleepers are used; the former in cuttings, the latter on embankments. The blocks intermediate contain each four, and the joint-blocks five cubic feet. The latter are occasionally placed in a diagonal position, and the intermediate blocks in a parallel position. The sleepers are of larch, 9 feet long, and measure about 10 inches by $4\frac{1}{2}$, being half logs. The rails are set in chairs, and secured thereto by wooden keys $6\frac{1}{2}$ inches long, 3 inches wide, and 2 inches thick. The ballasting is chiefly of broken stone. The fencing consists of stout wooden posts and three rails; the posts being 4 feet in length, 5 inches wide, and $2\frac{1}{2}$ inches thick, and fixed at intervals of about 8 feet 6 inches.

LOCOMOTIVE ENGINES.—The locomotive engines belonging to this railway differ, it will be seen, from those of the Ayrshire line, the former being six-wheeled, the latter four-wheeled engines. The proportions of those belonging to the Greenock line will be found in Table V. in the Appendix. It is to be hoped that the excellent opportunities which the joint committee will have of testing the two descriptions of engines between Glasgow and Paisley will not be lost sight of; and that a regular register will be kept from

day to day of the loads, speeds, and consumption of fuel of each class of engines respectively, as well as the cost of repairs.

ORIGINAL ESTIMATE.—The estimated expense of this line in the autumn of 1837, which was the year in which the Company obtained the Act of incorporation, is here introduced in order that it may be compared with the actual cost.

Property for main line	£ 77,235	0	0
Earthwork	66,135	0	0
Three tunnels and two archways	22,004	0	0
Ironwork	46,778	0	0
Masonry in bridges, &c.	55,000	0	0
Blocks, ballasting, and rails-laying	42,551	0	0
Altering roads, &c.	6,295	0	0
Fences, field-gates, retaining-walls, &c.	22,108	0	0
Extra walling through Erskine	1,050	0	0
Depots, stations, &c.	18,729	0	0
Branch to Greenock Harbour	8,000	0	0
Ditto to Port Glasgow	2,000	0	0
Contingencies	33,115	0	0
	<u>£401,000</u>	<u>0</u>	<u>0</u>

It will be observed that in the above estimate there is no allowance for engines and carriages.

The expected income from passengers and goods, at reduced railway charges, was estimated at 93,511*l.* 1*s.* 4*d.*, or at river and canal charges at 117,154*l.* 12*s.* 6*d.* The annual cost of working the line was estimated at 43,511*l.* 1*s.* 4*d.*; though in Parliament it had been proved that the annual expenses would only amount to 33,841*l.* 8*s.* 6*d.*

The following is an analysed account of the cost of the undertaking up to 30th May, 1840, including two Acts of parliament, &c.; the items for construction, &c. being in the order of their magnitude.

Works, including earthworks, bridges, culverts, masonry, } brickwork, blocks, sleepers, fencing, ballasting, &c. . }	£ 202,804	14	7½
Land and compensations	117,819	11	1
Rails and chairs	29,378	9	5
Law-charges, counsels' fees, parliamentary agents, &c. .	12,193	5	2½

GLASGOW, PAISLEY, AND GREENOCK RAILWAY.

Engineering and surveying, &c.	£8,817	6	7½
Interest on paid-up shares and on loans	4,174	6	7
Witnesses in parliament	2,623	7	4
Advertising, printing, engraving, &c.	2,106	10	11½
Office-charges, including salaries and furniture	1,800	8	10½
Deputation to London, and miscellaneous	1,794	19	9½
Agency, &c.	1,539	2	11
Valuator's charges, including deputation to Liverpool	1,055	3	2½
Direction	1,000	0	0
Expenses of taking traffic	834	1	1½
Police, including missionary and surgeon at Bishopton	647	8	4½
Travelling charges and expenses	218	3	2½
Stationery	114	10	11
Sundries	72	0	2½
Amended Act of Parliament	1,228	11	3
Carriages and wagons	1,371	16	1
Locomotive engines	2,601	10	0
	<u>£393,835</u>	<u>3</u>	<u>9</u>

This sum of 393,835*l.* 3*s.* 9*d.* is already within a few thousands of the original estimate, and the railway is very far from being finished. In this amount is included but a very small sum for carriages and locomotive engines. It is to be observed that only half the cost of that part of the line between Glasgow and Paisley is included in this amount. If we add the other moiety, the whole cost of the railway between Glasgow and Greenock, up to the 30th May, 1840, will be 498,142*l.* 10*s.* 6*d.*

THE GRAND JUNCTION RAILWAY.

Acts for the incorporation of two of the most important railway Companies in the kingdom received the royal assent on the sixth day of May, one thousand eight hundred and thirty-three. These Acts authorised the construction of the London and Birmingham and Grand Junction Railways, the estimated cost of which, extending together a distance of one hundred and eighty-nine and a half miles, amounted to three millions five hundred

and forty thousand pounds. The estimate of the former was 2,500,000*l.*, or 23,318·38*l.* per mile; and of the latter 1,040,000*l.*, or 13,333·33*l.* per mile; whereas the London and Birmingham Railway has cost fifty thousand six hundred and fifty-two pounds, and the Grand Junction Railway nearly twenty-three thousand two hundred and two pounds per mile.

The great disparity in the cost per mile of these two lines is chiefly owing to the difference of country intersected in the two cases, as well as the difference of gradients. Between London and Birmingham the works are of an extraordinary character, whereas between Birmingham and Newton there are comparatively few works of magnitude. The prevailing gradient of the London and Birmingham Railway is *sixteen feet*, whereas on the Grand Junction line there are gradients of *twenty, thirty, and sixty-two feet* respectively.

It is clearly more advantageous, in most cases, to graduate a line so as to render the works as light as possible, and thus cause the original outlay to be comparatively small, than to effect a complete system of gradients for the purpose of reducing the annual expenditure: it must ever be borne in mind, that this addition to the original outlay also requires an annual charge in the shape of interest.

These lines serve well to illustrate the two systems; and the results of future years' experience will throw much light on this branch of railway-engineering, which is at present but in a comparatively infant state.

ACTS OF PARLIAMENT. — Besides the original Act, which empowered the Grand Junction Railway Company to raise in joint stock a capital of 1,040,000*l.*, and by loan 346,000*l.*, they have subsequently obtained further power to raise by loan 520,000*l.*: this second Act received the royal assent on the 16th of June, 1834. The sums thus authorised to be raised amount altogether to 1,906,000*l.*

GENERAL COURSE OF THE LINE. — Leaving the station in Curzon Street, Birmingham, the line passes on the right of Aston, close to Perry Bar, and between Wednesbury and Walsall; and curving to the right of Wolverhampton, proceeds thence nearly in a direct line to Stafford, where it recurves and passes between Eccleshall and Stone; thence continuing on to Whit-

more and Madeley, is produced to Crewe, where the Chester line diverges to the left; from Crewe, in a slightly curving course, the main line is traced by Hartford and Preston Brook to Warrington, which is the end of the original line; from Warrington it is continued past the Vulcan Foundry, belonging to Messrs. Tayleur and Co., as far as Newton, where it joins, by two curved branches, each of about 10 chains radius, the Liverpool and Manchester Railway,—the distance from Birmingham to Warrington being 78 miles; from Birmingham to Newton 82·63 miles; and from Birmingham to Liverpool or Manchester 97·50 miles.

INCLINATIONS.—Commencing at Birmingham, the line makes the first dip at Aston, thence rises to Wolverhampton, and by a second dip reaches Stafford, from whence it ascends to the summit-level at Whitmore; the third dip is at Vale Royal, beyond which is a rise to Hartford, from which place the line descends to Dutton; thence slightly rises to Bird's Wood, again descends as far as Warrington, rises gently to Jockey Lane, makes the last dip at Dallum Brook, and finally rises to the northern terminus at Newton.

In the whole length of 82·63 miles there are twelve level planes, amounting together to 10 miles 47·44 chains; twenty-three descending planes, amounting in length to 41 miles 58·18 chains, and varying in inclination from 1 in 100 to 1 in 3474; and fifteen ascending planes, varying in inclination from 1 in 85 to 1 in 3300, and extending together 30 miles 24·93 chains. Of the descending planes the steepest are, first, that of 1 in 100 at Preston Brook, which is only for a quarter of a mile in length; second, the Madeley Incline of 1 in 177, which is 3 miles 20·90 chains in length; third, the Basford Incline, which is between the Madeley and Crewe planes, and extends for 3 miles 3·72 chains, the inclination being 1 in 265; and lastly, that between Bird's Wood and Preston Brook, which is 1 mile 7 chains in length, and inclines at the rate of 1 in 180: the remaining planes descending from Birmingham have all first-class gradients.

In the ascending planes are included only two which have gradients under the first class; these are at Burton Wood and Newton Brook, both lying between Warrington and Newton; the former being 21 chains in length, and inclining at the rate of 1 in 209; and the latter having an inclination of 1 in 85, and extending for one mile. Thus the descending

planes amount in length to 30 miles 24·93 chains, the ascending planes to 41 miles 70·63 chains, and the level planes to 10 miles 47·44 chains.

EARTHWORKS, BRIDGES, AND VIADUCTS. — The line throughout alternates in cutting and embankment, a circumstance very favourable in executing earthworks. Some of the embankments have an earthen mound on either side, similar to those on the Liverpool and Manchester Railway. The width of cuttings and embankments at level of rails is about 30 feet. There have been some heavy slips in those parts of the line where the strata consist chiefly of soapy clay and loam. The slopes where these have occurred will, in all probability, cause considerable trouble and expense for some years to come.

On our view of this line we counted one hundred and six bridges over and sixty-three under the railway, and seventeen level crossings. The principal works in the bridge-building department are the Weaver, the Dutton, and the Birmingham viaducts. There is a tunnel at Wolverhampton of 200 yards in length; and one at Preston Brook of about 40 yards.

The Lawley Street viaduct, leaving the Birmingham station, is built of brick, with stone quoins and dressings, and consists of twenty-eight segmental arches, of 30 and 30½ feet span respectively, the length extending to about 1000 feet, the height being about 20 feet, and the extreme width about 32 feet; the parapets are 3 feet 6 inches high and 18 inches in thickness: the whole is built on a curve of three quarters of a mile radius. The bridges, generally, are built of brick and stone; and where over the railway, are of 30-feet span.

GAUGE OF WAY, RAILS, &c. — The gauge of way is 4 feet 8½ inches; the intermediate space is 6 feet in width; and the side-spaces vary in width from 2 feet 9 inches and 3 feet 3 inches at the stations, to 6 feet 6 inches and 7 feet 8½ inches respectively on other parts of the line. The rails are of the double parallel form, of somewhat different sections (see Plate III. figs. 15, 16, and 17); they are set in chairs, and fastened thereto by wooden keys, those for the joint-chairs being each 6 inches, and those for the intermediate chairs 3½ inches long; the chairs are based either on stone blocks or cross sleepers, and secured in the usual way. The ballasting consists chiefly of gravel and sand, the whole thickness being nearly two feet. The

fencing consists chiefly of wooden posts with three rails and two intermediate wires: the stations are enclosed chiefly with space and pale fencing and brick walling. The mile-standards are of wood, 3 feet high above ground, 12 inches wide, and 6 inches thick, and are placed at intervals of a quarter of a mile on one side of the line, and the divisions of townships on the other.

STATIONS AND DEPÔTS.— Besides the terminal stations, there are the following intermediate stations, viz.:— Wolverhampton, Stafford, Whitmore, Crewe, Hartford, and Warrington, which are first-class stopping-places; and Perry Bar, Newton Road, Bescot Bridge, James Bridge, Four Ashes, Spread Eagle, Penkridge, Norton Bridge, Madeley, Basford Heath, Minshull Vernon, Winsford, Acton, Preston Brook, and Moore, which are second-class and mixed stopping-places.* Thus there are six intermediate first-class and fifteen intermediate second-class and mixed stations.

At Liverpool and Manchester the booking-offices of the Grand Junction Company are under the same roofs as those of the Liverpool and Manchester Railway. At Edgehill station, this is also the case; and the coach-building and repairing establishment is in Crown Street. The goods-depôts, both at Liverpool and Manchester, are also contiguous to those of the Liverpool and Manchester Railway.

The intermediate stations throughout are generally constructed in an economical, yet sufficiently convenient manner. The offices are built in the cottage style, and without any pretensions to studied design. It were well if this plan was more generally attended to: it really seems on some lines as if money was the last thing thought of, the aim being evidently to make as much architectural display as possible.

At Warrington is the principal intermediate station; it is situate close to the bridge which carries the turnpike-road over the railway at that place:

* Taken in order from Birmingham, the different stations are distant from that place as follows:—Perry Bar, 3 miles; Newton Road, 6½; Bescot Bridge, 9; James Bridge, 10; Wolverhampton, 14; Four Ashes, 20; Spread Eagle, 21; Penkridge, 24; Stafford, 29; Norton Bridge, 35; Whitmore, 43; Madeley, 46; Basford Heath, 51; Crewe, 54; Minshull Vernon, 59; Winsford, 61; Hartford, 66; Acton, 68; Preston Brook, 72½; Moore, 75; Warrington, 78; and Newton Junction, 82 miles 5 furlongs.

the whole length is upwards of 100 yards, and the breadth about 40 yards. The main double way runs under the centre arch of the bridge, the *down* line being within 2 feet 9 inches of the waiting-rooms' platform on the left going towards Liverpool, and the *up* line 26 feet 6 inches from the platform of the booking and other offices. From the up line a siding runs off to communicate, by means of turn-tables, with the carriage-dock and carriage-house, which are situate on either side of the bridge; the carriage-dock is about 43 feet in length, intended to hold either two carriage-trucks or horse-boxes at a time; but the width is much too little, being only about 8 feet. This will, no doubt, be altered at a convenient season. The carriage-house is 58 feet in length and 22 feet wide, with a double way within, capable of holding altogether twelve carriages. The booking-office and ladies' waiting-room are set back 12 feet 6 inches from the front line of platform: the conveniences are detached from this building, and are placed in far too conspicuous a situation; they might easily be removed to a less exposed place at the back of the offices. On the *down* side are two small waiting-rooms, enclosed under a shed-roof, which extends altogether 116 feet, and is 10 feet in width. This building is distant from the Warrington Bridge $26\frac{1}{2}$ feet. The coke-wharf is on the same side as the booking-office, and removed from it about 60 feet: it is furnished with a single line of way at right angles to the front of the wharf. On this way is placed a movable 6-inch wooden platform, enclosed on three sides, which runs on four wheels, each of 16 inches diameter. The length of this platform is 10 feet, the depth 8 feet 9 inches, and the height of the sides and back 5 feet 7 inches; within are three stages, two of which are 6 feet long and 4 feet wide, and that in the middle is 4 feet long and $2\frac{1}{2}$ feet wide: these stages together will hold 24 sacks of coke. From this platform the coke is readily put into the tenders.

There is also a fixed coke-stage under the centre arch of the bridge, which is $3\frac{1}{2}$ feet high, 3 feet 10 inches wide, and 45 feet long; it will hold 80 sacks of coke, each weighing 112 lbs.

On either side of this station there is a water-column 11 inches in diameter; on the top of that on the *up* side is fixed a lamp; and there is also a bell hung underneath the lamp.

The establishment at this station consists of a superintendent and two

clerks, a manager, three porters, one policeman, four shuntmen, four coke and water-fillers, one coach-greaser, and two gate-porters.

The Whitmore station is in cutting, and is approached from the turnpike-road by a sloped carriage-way. The whole length of this station is about 276 feet, and the width about 55 feet. The offices, which are on the *down* side, consist of a booking-office and general waiting-room, and a ladies' room contiguous, with proper conveniences. There is also a range of five urinals on the *up* side. The width between the down and up platforms is 22 feet 6 inches. There is a coke-shed and also a water-column at either end of the station, on opposite sides. There is also a carriage-landing and a carriage-house; a stationary pumping-engine is fixed in a building contiguous to the carriage-house.

In 1839 every train stopped at this station to take in coke and water.

The establishment consisted of two ticket-collectors, one policeman, six coke and water-fillers, one pointsman, two porters, and one stationary engine-man.

The Crewe station is very similar in plan to that of Whitmore.

At the Stafford station, in addition to the offices, which are somewhat similar to those at Whitmore, there is a waiting-shed for passengers on the down side, and also a locomotive engine-house furnished with friction-wheels.

The Hartford station is very inconveniently situate in deep cutting near the bridge which carries the turnpike-road from Manchester to Chester over the railway: it is approached by a sloped carriage-road; and there is also a flight of steps for passengers arriving or departing on foot.

The principal goods-depôts are situate at Liverpool, Manchester,* and Birmingham.

The Birmingham goods-depôt is at Duddeston, about half a mile from the terminal station in Curzon Street, and near to the locomotives' engine-house on the left side of the way leaving Birmingham. This building is approached by a siding from the main line, which is furnished with two eight-feet turn-tables and a weigh-bridge; from the turn-tables two parallel lines of rails run towards the back of the building in a proper dock, 3 feet

* See description of Liverpool and Manchester Railway.

4 inches high from level of rails. This dock is returned at the end, and the communication throughout is effected by two additional turn-tables at the meetings of the cross line with the two lines emanating from the siding. Each of these two lines will hold ten wagons, and the cross line four; so that not less than 80 tons of goods can be loading or unloading at the same time. Cranes are conveniently placed on the different wharfs adjoining these docks.

There are about thirty men employed at this depôt. In the rear of the goods-building there is stabling for fifteen horses.

CARRIAGE DEPARTMENT. — At the close of the year 1839 the Company's stock of carriages consisted of twelve mails, two post-office carriages, one post-office tender, fifty-four first-class carriages, thirty-seven second-class carriages, fourteen third-class carriages, ten parcel-carts; two hundred and forty merchandise-wagons, calculated to carry from 4 to $4\frac{1}{2}$ tons; two hundred and sixty goods, cattle, and coke-wagons, calculated to carry 4 tons of goods, from 15 to 72 pigs, from 30 to 40 sheep, from 5 to 7 cattle, or from 4 to 5 tons of coke; two bullion-wagons, calculated to carry each 4 tons; four parcel-vans, calculated to carry $3\frac{1}{2}$ tons each; fifty carriage-trucks; and fifty horse-boxes, each capable of holding three horses.

The total estimated value of the above stock is 100,949*l.* 10*s.* 11*d.*

The mails are of exceedingly neat design (see Plate XII.), and will each hold ten passengers: they consist of two whole compartments, and one coupé in front. The weight of a mail is 3 tons 12 cwt., and the cost 440*l.*

The first-class carriages are in three whole compartments, each of which will hold six persons, or eighteen altogether; the weight is $3\frac{1}{2}$ tons, and the price 410*l.* The length of the body is 15 feet 6 inches, the width 6 feet 7 inches, and the under carriage is 20 feet in length. (See Plate XII.)

The second-class carriage is in three compartments, which are roofed in, and closed at the sides and ends; it will hold twenty-four passengers; the weight is 3 tons, and the price 330*l.*; the length of the body being 13 feet, and of the under carriage 17 feet 4 inches, and the width of body 6 feet 5 inches.

The third-class carriages are also in three compartments, and hold the same number as those of the second class, but have neither roofs nor sides;

but the seats are as comfortable as in the second-class carriages. The length of the third-class body is 13 feet 6 inches, and of the under carriage 15 feet 8 inches; and the width of the body is 6 feet 1 inch. The weight is about 2 tons, and the cost 160*l*.

The post-office carriage,* which is conveniently arranged for the clerk and assistant, is in two compartments; the one being fitted up with several ranges of sorting-boxes, desk, cupboards, &c.; and the other being furnished with a desk for the assistant, and containing sufficient space for the bags to be taken up or left on the journey. The entrance is in the middle of one side; the whole is fixed on an under carriage, mounted on four wheels, each of 3 feet diameter, the axles being 8 feet 6 inches from middle to middle. The weight is 4 tons 1 cwt. 2 qrs., and the cost 460*l*. The length of the body is 15 feet 7 inches, the width 7 feet 7 inches, and the height 7 feet. The under carriage is 19 feet 6 inches long.

The post-office tender, which is for the conveyance of the *through* letters and newspapers, is 9 feet 7 inches long, 7 feet 7 inches wide, and 7 feet high; the under carriage being 12 feet 9 inches long, and 6 feet 2 inches wide. There is neither spring buffing, nor drawing apparatus; the buffers are composed of solid blocks of wood, finished with leather cushions, and stuffed with horse-hair; the weight is 2 tons 7 cwt., and the value 120*l*.

The whole of the above-described carriages, except the post-office tender, are fitted up with spring buffing and traction apparatus (see Plate XII.), and are mounted on Losh's malleable iron wheels of 3 feet diameter, weighing about 20 cwt. per set. About two-thirds of the whole number of carriages are furnished with brakes. Mr. Worsdell, Jun. is the superintendent of the carriage-building and repairing department.

The merchandise-wagons, or trucks, are each 9 feet 9 inches long, 7 feet 2½ inches wide, and 9¼ inches high; the price of each is about 63*l*., and the weight about 2 tons 3 cwt.

The cattle and coke-wagons, the sides and ends of which are formed with upright standards and wooden rails, are each 9 feet 9 inches long, 7 feet 2½ inches wide, and 5 feet 3½ inches high; the price of each being about 71*l*., and the weight 2 tons.

* See description of post-office in account of London and Birmingham Railway.

The carriage-trucks are each 13 feet 8 inches long, 7 feet $1\frac{1}{2}$ inches wide, and the sides $1\frac{1}{2}$ inches high; the weight being about 43 cwt., and the price 130*l*. The carriages are secured to the trucks by three ropes on each side.

The horse-boxes will each hold three horses. They are furnished with movable partitions which separate the horses from each other; the horses are secured with leather straps. The size of a horse-box (No. 31) is 9 feet 6 inches long, 8 feet wide, and 6 feet 10 inches high; the wheels are 2 feet 6 inches in diameter, the weight is about $2\frac{1}{2}$ tons, and the price about 98*l*.

The bullion-wagons are each 4 feet 10 inches long, 3 feet 6 inches wide, and 2 feet 5 inches high; the price being about 70*l*.

The parcel-vans are each 9 feet 9 inches long, 5 feet 9 inches wide, and 5 feet 6 inches high; the weight being about 3 tons, and the value 70*l*.

FARES AND PASSENGER TRAFFIC.—The maximum fares for passengers allowed to be taken by the Company's Act are at the rate respectively per mile of $3\frac{1}{4}$ *d*. for mails, 3*d*. for closed carriages, and $2\frac{1}{4}$ *d*. for open carriages. The fares charged by the Company are 2·80*d*. per mile for mail-passengers, 2·50*d*. for first-class, 2·10*d*. for second-class, and 1·33*d*. for third-class passengers respectively.

From 31st December, 1837, to 1st February, 1840, inclusive, the number of passengers conveyed on this line amounted to 957,020, or at the rate, on an average, of 1254·28 per diem.

From 28th April, 1839, to 1st February, 1840, inclusive, the number of passengers was 385,182; and the receipts for the same period on this account were 131,368*l*. 18*s*., or at the rate of 469*l*. 3*s*. $5\frac{1}{4}$ *d*. per diem.

The proportion of first-class to second-class passengers was rather more than 2 to 1; of first-class to mail passengers about 15 to 1; and of first-class to third-class passengers nearly as $16\frac{1}{2}$ to 1.

RECEIPTS AND EXPENDITURE.—In 1838 and 1839 the receipts for passengers, parcels, horses and carriages, and conveyance of mails, amounted to 611,011*l*. 17*s*. 11*d*.; for goods to 93,398*l*. 16*s*.; for live stock 13,990*l*. 11*s*. 6*d*.; and for tolls to 672*l*. 10*s*. 6*d*.; together, 719,073*l*. 15*s*. 11*d*., or, on an average, at the rate of 985*l*. 0*s*. $7\frac{1}{2}$ *d*. per day.

The gross receipts for 1838 and 1839 reached the sum of 724,713*l.* 7*s.* 5*d.*, and the expenditure for the same period 401,278*l.* 1*s.* 8*d.*; being about 55·53 per cent on the gross revenue. For these two years the net profit amounted to 331,645*l.* 5*s.* 4*d.*, or 454*l.* 6*s.* 2*d.* a day, the gross receipts being 992*l.* 15*s.* 1½*d.*, and the expenses 549*l.* 13*s.* 11*d.* per diem respectively.

LOCOMOTIVE ENGINE DEPARTMENT.—The chief locomotives-establishments are at Liverpool and Birmingham. That of Liverpool is situate at Edgehill, contiguous to the locomotives-depôt of the Liverpool and Manchester Railway. A new engine-house was erected at this place in 1839, which is about 192 feet long, 42 feet wide, and 16 feet high. It is furnished with three lines of way, and is lighted by eleven windows on either side, the doors being at each end. The turnery, smithy, and repairing shops, are in a building nearer to the locomotives-establishment of the Liverpool and Manchester Railway, and are entered from a siding having four turn-tables, from which as many lines run into the shed.

The Birmingham locomotives-depôt* is contiguous to that for the goods at Duddeston. There are four sets of rails at this part of the line, which is on an embankment, supported by retaining walls built to a curved batter; the clear width between parapets being 59 feet 3½ inches.

The engine-shed is on the left side going from Birmingham, and the coke-shed on the right.

The engine-house has two lines of way running through it, each of which will hold three engines, and as many tenders. One line is furnished with a race. There is an engine turn-table at this dépôt of 13 feet diameter.

The coke-shed is 84 feet in length, 20 feet wide, and 10½ feet high. The floor, which is formed with asphalte of Seysell, is three feet above the level of rails. The roof is supported in front by stout wooden posts, 11 feet asunder, the spaces between which are occupied by sliding-doors. This building will hold about 80 tons of coke, properly piled.

The railway is altogether worked by six-wheeled engines, sixty-four in

* At the Birmingham locomotives-depôt the establishment consists of a superintendent, a time-keeper, four fitters by day and two by night, one smith, one striker, one brazier by day and one by night, two carpenters, four boys, four engine-movers who also light the fires, seven cleaners, six coke-fillers, four points-men, one policeman, seven engine-drivers, and seven firemen or stokers.

number, furnished by first-rate makers. Their proportions will be seen by reference to Table No. VI. of British locomotives in the Appendix.

Both Worsley and Hulton's cokes are used, the cost being 26*s.* a ton; and the average number of tons consumed per diem, including Sundays, about 54, or for six days a week 59·36 daily. The number of trains daily in each direction, except Sundays, is seven, including one for goods; on Sundays there are three trains in each direction; and the distance from Birmingham to Liverpool or Manchester may be taken at 97½ miles; so that the number of miles run by this Company's engines is 1365 per working day, and 585 per Sunday, besides those used to assist, or in piloting.

We found the average gross weight of twenty-three passenger-trains on this line to amount to 77,901 lbs. (see Table F. of Results of Practical Experiments, in Appendix). Taking this weight as an average for the passenger-trains, and 155,802 lbs. for the goods-trains, the number of passenger-trains being twelve and of goods-trains two, we have 77,901 lbs. \times 12 + 155,802 lbs. \times 2 = 1,246,416 lbs. gross, conveyed 1365 miles by 132,966·40 lbs. of coke, or at the rate of only 0·175 lb. of coke per ton per mile.

We found the average velocity of twenty-four trains to amount to 26·20 miles an hour, and the stoppages to average each 4·049 minutes. Some of the mixed trains stop as many as twenty times, but the mail-trains stop only five or six times. The speed of luggage-trains is limited to 12 miles an hour.

The number of miles run by the Company's engines in a year, taking fourteen trains daily for six days in a week, and six trains on Sundays, is equal to 457,665, or at the rate of 7627 miles for each engine, taking sixty engines; which, supposing an engine to run 97½ miles a day (although some exceed that distance considerably) gives nearly 78·22 days as the average time of each being at work. Further, the number of single trips of 97½ miles will be 4694 per annum; and allowing each engine to work for about 120 days per annum, it will require about thirty-nine engines to be constantly at work, and the remaining twenty-one either at rest or under repair.

The gross weight drawn by the engines per annum, according to the above data, will be 414,433,320 lbs., or 185,014·87 tons.

SHARES, STOCK, COST OF LINE, &c.—The number of original shares in this Company is 10,400 of 100*l.* each; the number of Warrington and New-

ton shares 518, also of 100*l.* each ; 10,918 half shares ; 5,000 Chester Branch quarter shares ; and 17,627 new quarter shares. Thus the whole of the Company's stock will be 2,203,375*l.* The cost of the railway, up to 30th June, 1839, was stated to be as follows :—

Engineering, surveying, land and compensations, parliamentary and legal expenses, construction of line, including rails, chairs, stations, &c.	} £ 1,607,541	1	5
Locomotive engines, tenders, and buildings for same	113,740	3	6
Carriages, wagons, trucks, horse-boxes, and erections for same	112,480	18	11
Purchase of Warrington and Newton line	65,463	7	4
Interest on loans previously to the completion of the line	22,270	18	3
	<u>£ 1,921,496</u>	<u>9</u>	<u>5</u>

It will be observed that the first item includes the whole of the expenses in completing the railway ; and the second and third items are, as it were, for the furniture. It is much to be regretted that we are not able to dissect the first item ; but it is unfortunately too much the custom at present to make out the accounts in this wholesale style.

The expenses of working the line for eighteen months, ending 30th June, 1840, were as follows :—

Coaching disbursements, including repairs and police	£ 66,544	12	11
Merchandise disbursements, including commission to agents, repairs of wagons, &c.	} 30,575	6	11
Locomotive power, including engine and firemen's wages, repairs, and cost of materials	} £ 66,085	1	5
Coke	38,493	4	3
	<u>104,578</u>	<u>5</u>	<u>8</u>
Maintenance of way	30,772	14	8
Repairs of stations and cottages	1,625	12	1
Office and general expenses, including insurance, advertising, and general disbursements	} 9,306	0	6
Direction	1,368	3	0
Engineers' salaries	2,699	17	9
Compensation	3,928	9	2
Rates and taxes	7,446	8	7
Rent	4,444	19	3
Travelling expenses	202	7	2
Law expenses	1,897	8	4
Toll to the Liverpool and Manchester Railway Company	30,979	15	1
	<u>£ 296,370</u>	<u>1</u>	<u>1</u>

Thus the average annual expenditure in working this railway, according to the above statement, is 197,580*l.* 0*s.* 8½*d.*, or about 541*l.* 6*s.* 3*d.* per diem; of which sum disbursements in the coaching department amount to about 121*l.* 10*s.* 10*d.*; in the merchandise department to 56*l.* 2*s.* 4½*d.*; in the locomotive department to 191*l.* 0*s.* 2½*d.* (the coke being 70*l.* 6*s.* 1½*d.*); the maintenance of way to 56*l.* 4*s.* 1½*d.*; the Liverpool and Manchester Railway toll to 56*l.* 11*s.* 8½*d.*; and the remaining 59*l.* 17*s.* ¼*d.* consists of the following items, viz. repairs of stations and cottages, office and general expenses, compensation, rates and taxes, rents, travelling expenses, and law expenses.

This railway was executed under the general direction of Mr. Locke; and the working of it is entrusted to the superintendence of Captain Cleather, who is ever attentive to the interests of the Company, and at the same time always ready to promote the comfort and convenience of the public by every means in his power.

GREAT NORTH OF ENGLAND RAILWAY.

THE year eighteen hundred and thirty-six will ever occupy a conspicuous page in the history of British railways. Twenty-nine Acts received the royal assent in the session of that year for the formation of new lines, the estimated cost of which amounted to twenty-three millions two hundred and eighty-three thousand six hundred and sixty-five pounds. Of this number, nineteen are already either wholly or partially opened to the public; and the rest, with the exception of three, are in a state of rapid progress of construction.

The Great North of England Railway is included in the railway catalogue of 1836, and may unquestionably be classed with the principal lines in the kingdom, forming an important link in the grand northern trunk between London and Edinburgh.

As originally planned, it embraced an extent of 113 miles 72·36 chains, the main line from Newcastle to York being 75 miles 50 chains in length; the York and North Midland Branch, 77·36 chains; the Thirsk Branch,

1 mile 30 chains; and the junction-line to Leeds, diverging from the main line at Wood End, 35 miles 75 chains.

Mr. Storey's estimate for the whole extent of railway-communication thus contemplated amounted to 1,700,570*l.*, or at the average rate of only 14,930*l.* per mile. This estimate included a double line throughout, and land for four lines; a plan which had already been adopted in the case of the Leeds and Selby Railway. The important item of locomotive engines and carriages was, however, altogether omitted in the estimate; a practice attended with considerable inconvenience.

The most expensive part of the main line, according to the above-mentioned estimate, was that lying between the Tyne and Hurworth Lane, a distance of 34 miles 34 chains, which was set down at 659,851*l.*, or upwards of 19,000*l.* per mile; while the remaining length, from Hurworth Lane to York, which is the part at present executing, was calculated at only 7,921*l.* per mile.

ACTS OF PARLIAMENT. — This Company obtained an Act for making a railway from Newcastle to near the river Tees, at Hurworth Lane, which received the royal assent on the 4th July, 1836, and authorised a capital of 1,000,000*l.* to be raised in joint stock, and an additional sum by loan of 150,000*l.*; and in the following session they applied to Parliament for a second Act, which empowered them to raise a further sum of 180,000*l.* In this application they were also successful.

The total sum thus authorised to be raised amounts to 1,330,000*l.* It is to be observed, that in the original Act the capital of 1,000,000*l.* was for the construction of the whole line from Newcastle to York, together with the junction-line to Leeds; but the part lying north of Darlington and the Leeds Branch appear to be abandoned for the present.

COURSE OF THE RAILWAY. — From its junction with the York and North Midland Railway at Hob Moor, the line is carried, with a curve of about a mile and a half radius, as far as Acomb, where the York City Branch diverges. From Acomb it is continued in a direct line to the east of Poppleton Church, near which it crosses the river Ouse, passing close on the right of Spring House, in the township of Raskelf, and a little to the west of

Lees Barn, in the same township; thence, intersecting Pill Moor, in the parish of Brafferton, passes through the parishes of Sessay and Kirby Knowle, and continues on to the west, and one mile from Thirsk; thence, slightly curving to Pasture Field, in the parish of Kirby Wiske, takes a direct course through South and North Otterington parishes and to the west of North Allerton, passing between that town and Romanby; thence, by Castle Hill, in a continuous straight line to the right of Hutton Bonville Hall, in the parish of Birkby, slightly curving to the west of Birkby, crossing the river Wiske near that place, and continuing in a direct course to a point close on the right of Pepper-field House, in the parish of Croft; from whence, by a reversed curve, with radii of a mile each, it proceeds to its junction with the Croft Branch of the Stockton and Darlington Railway, which, however, now forms part of the Great North of England line, having been purchased by this Company for 20,000*l*.

INCLINATIONS. — The following table exhibits the length and inclination of each plane, commencing at the junction with the York and North Midland Railway at Hob Moor: —

Lengths of Planes.		Ratio of Inclination.			Locations.	
Miles.	Chains.					
1	13·00	descending at the rate of 1 in	776		{ Divergence of York City Branch.	
2	14·00	ascending	1 in	1178	River Ouse.	
8	72·00	ascending	1 in	3473		
5	28·00	ascending	1 in	804		
4	61·00	ascending	1 in	11,000	{ Turnpike - road, Thirsk to Ripon,	
2	02·70	level				
5	62·00	ascending	1 in	628	{ Turnpike-road, Northal- lerton to Boroughbridge.	
4	41·00	descending	1 in	1269	{ Private carriage-road to Hutton Bonville.	
4	15·00	ascending	1 in	600		
2	58·00	descending	1 in	394	Hurworth Lane, Croft.	
2	68·00	ascending	1 in	458	Croft Branch.	
0	50·50	ascending	1 in	508	Darlington Station.	
45	05·20					

Thus the present main line is little more than 45 miles in length, with

inclinations varying from 1 in 394 to 1 in 11,000; and the York City Branch is 78 chains long, and rises from the main line at the rate of 1 in 523.

The whole are, therefore, first-class gradients, which, together with the almost entire absence of curves, will render this a very safe line, and also an economical line as regards locomotive power.

EARTHWORKS, BRIDGES, &c. — The excavations amount altogether to 1,448,000 cubic yards, which is under 32,000 yards per mile.

The principal works in this department are the Dalton cutting, containing 368,742 cubic yards; the Tees embankment, which amounts in quantity to 56,454 cubic yards; the Castle Hill cutting, to 55,971 yards; and the North Allerton embankment, to 252,641 yards.

The principal bridges are those over the rivers Tees and Ouse. The former is a handsome oblique structure, consisting of five large segmental arches, built of sandstone from Gatesley Moor, and is from the design of Mr. Welch, county surveyor for Northumberland, under whose direction it has been carried into execution by Messrs. Dees and Hogg, of Newcastle, as contractors. The height from the surface of the water in the Tees is about 50 feet, and the angle of skew is 45°. That over the Ouse at Nether Poppleton is also chiefly built of stone, the heart of each abutment consisting of solid brickwork. The arches are three in number, and of semi-elliptical form. The height of the bridge from the bed of the river is about 30 feet.

This structure, which is of good proportions, was designed and executed under the direction of Mr. Green, of Newcastle, by the contractors, Messrs. Welch, of Gateshead. Travelling cranes were used in the construction of both these bridges.

There are forty-two bridges over and under the railway in about equal numbers, twenty-three culverts, and about fourteen level highway and occupation-crossings.

GAUGE OF WAY, &c. — The national gauge is necessarily adopted on this line, it being in connexion with the various links extending southward to the metropolis, the rails of which are all laid to the gauge of 4 feet 8½ inches. The rails are of the parallel form, and are fixed in large chairs, those for the intermediate points of support weighing 28½ lbs., and measuring 9 inches

by $8\frac{1}{2}$ inches; and the joint chairs each of 40 lbs. weight, and being 10 inches square. Each chair is furnished with four plug-holes at the angles, each of $1\frac{1}{2}$ inches diameter.

A novel mode of securing the rails to the chairs is adopted on this line. It consists of a solid block of cast iron, 2 inches in width, which is placed between the vertical flanches on one side of the chair, and close to the rail; through perforations in the flanches an iron wedge is passed, which runs close behind the block, and thus keys in the rail. This wedge is 7 inches long, one inch wide at top, $\frac{1}{4}$ of an inch at bottom, and $\frac{1}{2}$ an inch thick. Some of the rails have been supplied by the British Iron Company, at 11*l.* 12*s.* 6*d.* per ton; and the chairs were chiefly supplied by Messrs. Hawkes and Co., of Gateshead. Both stone blocks and wooden sleepers are used as footings for the rails.

Besides the terminal stations of York and Darlington, there are twelve intermediate stations, viz. Shipton, Tollerton, Alne, Raskelf, Sessay, Thirsk, Otterington, Northallerton, Danby Wiske, East Cowton, and Croft.

LOCOMOTIVE ENGINES. — The engines belonging to this Company are twenty in number, and were constructed by two of the principal builders in the kingdom, viz. Messrs. R. and W. Hawthorn, of Newcastle, and Messrs. Tayleur and Company, of the Vulcan Foundry, near Warrington. Their proportions will be seen by reference to Table No. VII. of British Locomotives, in the Appendix.

GREAT WESTERN RAILWAY.

THE Great Western Railway is by far the most gigantic work of the kind, not only in Great Britain, not only in Europe, but, we venture to say, in the whole world.

Mr. Brunel, not satisfied with the beaten track pursued by those who had gone before him, determined on carrying out this important work on entirely new principles; and, notwithstanding the numerous adversaries he

has had to contend with from every quarter, has thus far been eminently successful in his favourite project, and will, no doubt, ere another summer shall have passed away, pronounce this mighty work to be completed throughout.

But, while we thus acknowledge the praise so eminently due to this celebrated engineer for the skill he has displayed in the design and construction of the works, and for the straightforward and manly course he has hitherto followed, nothing daunted by the attempts of interested parties to crush his giant-child while yet in its infancy,—we should, indeed, have experienced much greater satisfaction if this object could have been attained at a cost little exceeding the parliamentary estimate. This estimate, it must be remembered, was examined by Mr. Stephenson, Mr. Walker, and Mr. Palmer, who had severally examined the country, and considered the prices liberal.

Mr. Saunders, the secretary of the Company, in his evidence before the Select Committee on railways in the session of 1839, mentions the following as causes for the excess over Mr. Brunel's original estimate: the London extension line, and the establishing of an independent terminus, which, together, cost nearly half a million of money; the greater heights and depths of earthworks for the purpose of improving the gradients, added to the consequent increased area of land; the additional cost of stations; and the execution of the works by night as well as by day. But Mr. Saunders omitted to mention the prime cause of this great increase, which is, in truth, the wide gauge. As far, however, as the public is concerned, there is great reason to rejoice; much is gained by the alteration, safety and expedition are thereby secured, while the fares are not above those charged on other lines.

ACTS OF PARLIAMENT, &c. — The Act for the incorporation of this Company received the royal assent on the 31st August, 1835, which authorised a capital to be raised in joint stock of 2,500,000*l.*, and by loan 833,333*l.* An amended Act was passed in the following session.

In 1837 two additional Acts were obtained; the one for making alterations in the line, and the other for extending it to an independent terminus at Paddington.

In 1839 the fifth Act of Parliament received the royal assent, and empowered the Company to raise an additional capital in half shares of

1,250,000*l.*, and by loan 416,000*l.* Thus the whole amount authorised to be raised amounts to 4,999,000*l.*

According to the prospectus of 1833, the capital was intended to be 3,000,000*l.*; but in the following year it was reduced to 2,500,000*l.*

On their first application to Parliament, in 1834, the Company met with considerable opposition; and the bill was thrown out, on the ground of its being only a half measure; for they had then only intended to make the railway as far as Reading; and seeing what has taken place with regard to other lines, it is not at all likely that it would, for a very long time, if ever, have been extended beyond that place. The Legislature, however, wisely said to the promoters, "You shall either make a complete Western Railway, or none."

In consequence of this wise determination of Parliament, the Company, with renewed vigour, set to work to prepare themselves for a second application in 1835; and notwithstanding the opposition they had still to encounter, the royal assent was given to the Act of incorporation at the very end of the session of that year.

One of the consequences of the adoption of the wide gauge was the absolute necessity of terminating the line in London at an independent station; for, until this was determined on, the Great Western Railway was to have joined the London and Birmingham line a few miles from London, and thus have saved a very considerable outlay, besides having a far more convenient London terminus. It is a well-known fact, that it occupies as much time in getting from the city to the Paddington station, as in going the whole way from Paddington to Twyford. The Euston station of the London and Birmingham Railway is far more central for the greater part of the metropolis; yet we are among the number of those who predict, at some future day, the extension of both these lines to a city terminus.

Some years ago we prepared designs for a subterraneous railway from Paddington to the city, with lateral and vertical side-shafts for ventilation, to follow nearly the course of the present road; but at that time the art of tunnelling was not so completely understood as it is at the present day; nor was the public mind so well prepared for such a radical change in metropolitan locomotion.

COURSE OF THE LINE.—Leaving the London terminus at Paddington, the

route of this way is traced to the south of Kensall Green, thence to Wormholt Scrubbs, Hanwell, Southall, West Drayton, Langley, Slough, Maidenhead, Twyford, Reading, Pangbourn, Goring, Moulsoford, Steventon, and Swindon, at a point near which the Cheltenham Railway diverges. From Swindon the line continues to Wootton Bassett, thence to Chippenham, Bathampton, Bath, and Bristol, terminating at the station in Temple Meads.

GRADIENTS AND LEVELS.—Mr. Brunel, in laying out this line, has paid the greatest possible attention to the gradients and curves, so as to present as little impediment as possible to the easy passage of the locomotive engine throughout. With the exception of 3·740 miles, of 52·80 feet per mile, there is no gradient from one end to the other steeper than 15·35 feet, or 1 in 344, and this only for a short length. From the Paddington station the line ascends 38 feet in 9·75 miles to a point beyond Southall, from whence it makes the first dip to Langley station, a distance from the London terminus of 15·889 miles, and at an elevation of 20·50 feet. The second summit, which is at Sonning Hill, is reached at a distance from London of 33·125 miles, and at an elevation of 77 feet. The line then dips towards Reading, a distance from the Sonning Hill summit of 3·439 miles, the elevation above the London terminus being 67·25 feet, and the whole distance 36·562 miles. From Reading, the next, which is the longest reach, extends to the summit of the line near Swindon, a distance of 40·492 miles, and at an elevation above the Paddington station of 263·67 feet. The third dip is to a point near Wootton Bassett, a distance from London of 90·880 miles, the elevation being 108·21 feet. The fourth summit is near Box, distant from the London terminus 98·463 miles, and at an elevation of 168·87 feet. Finally, the eighth reach descends to the station at Bristol: thus the whole distance from London is 117·40425 miles, or 117 miles 3 furlongs 2·34 chains, the fall from the London terminus being 27·33 feet.

The line is divided into fifty-seven planes, of which twenty are ascending from London, and have inclinations varying from 1 in 660 to 1 in 2640, their united lengths amounting to 67 miles 55·48 chains; twenty-three descending, the ratio of inclination ranging from 1 in 100 to 1 in 3933, and their whole length being 39 miles 56·92 chains; and fourteen level,

amounting in length to 9 miles 79·94 chains. The prevailing gradient is 4 feet; the ascending planes thus graduated amount in length to 21 miles 21·50 chains, and the descending planes to 13 miles 58·52 chains, together 35 miles, being little less than one-third of the whole distance. The gradient next in order, in point of length, is that of 8 feet, which is extended over five planes, amounting in length to 19 miles 33·41 chains; and there are 13 miles 40·61 chains laid out with a 7-feet gradient.

The two planes of 1 in 100, or 52·80 feet per mile, are situate at Wootton Bassett and Box: the former descends towards Bath for a length of 1 mile 29·09 chains; and the latter, through the tunnel, also descends in the same direction, and extends to Middle Hill tunnel for a length of 2 miles 30·15 chains.

EARTHWORKS.—The earthworks are upon the whole heavy; and the cost per cubic yard, which was originally estimated at 12*d.*, has turned out to be 19*d.* on an average throughout, which makes a serious difference in this item of expenditure.

In forming many of the embankments, side-cutting has been resorted to in preference to leading the materials for a considerable distance. This, of course, increases the quantity of land to be purchased, but expedites the progress of the works; and with regard to cost, it is a matter of easy calculation as to which is the most economical method. The slopes vary from vertical to 3 to 1, according to the nature of the strata. The cuttings are 38 feet wide at level of rails.

In the Bristol division the earthworks are particularly heavy, and include the following:—the cutting east of Brislington tunnel, in freestone, &c., containing 30,000 cubic yards, with vertical sides; the Keynsham Hams embankment, $\frac{1}{2}$ of a mile long and 30 feet high; the Saltford cutting, in blue lias, containing about 525,000 cubic yards; the Saltford embankment, 583,440 cubic yards, besides the spoil deposited chiefly on the south side, the whole being the produce of the Saltford and Twiverton cuttings; the Newton cutting, containing 87,000 cubic yards, in red marl; the Pennyquick embankment, 27,000 cubic yards; three small cuttings in Twiverton and Lyncomb parishes, amounting to 86,775 cubic yards; the Dole Mead embankment, east of Bath, containing 60,000 cubic yards; the cuttings between Dole's Mead

east and the eastern boundary of Bathwick parish, 144,900 cubic yards; the Bathampton western embankment, 52,000 cubic yards, the slopes being formed at 2 to 1; the Bathampton cutting, of 87,000 cubic yards, also with slopes of 2 to 1; the Bathampton eastern embankment, 120,000 cubic yards; and the Box Tunnel eastern cutting, containing 1,533,000 yards.

In the London division the cutting at Sonning Hill, to the east of Reading, is one of the chief earthworks. The embankments about Hanwell are for the greater part formed of gravel, the produce, to a considerable extent, of side-cutting from below the level of the works.

In Mr. Brunel's original estimate, the earthworks between London and Reading were calculated at 2,650,000 cubic yards, and were set down at 1s. per yard; and between Bath and Bristol they were estimated at 10*d.* a cubic yard, and the cubical contents amounted to 840,000 yards.

TUNNELS.—The most difficult and expensive work on this line is the tunnel through Box Hill between Bath and Chippenham. The vertical shafts were commenced in November 1836, and the tunnel itself in December 1838. The whole length of the tunnel is 3123·33 yards, or rather more than 1½ miles. The clear width at the level of the springing of invert is 27 feet 6 inches, and at 7 feet 3 inches above this line it is 30 feet; the clear height above the rails is 25 feet. Where bricked, the sides are constructed of seven rings, the arch of six rings, and the invert of four rings; the foundation is 36 feet in width. The surface of the ground at the eastern entrance is 69 feet 6 inches from the level of the rails; and that at the western entrance 64 feet.

The shafts are eleven in number. No. 1, which is on the western side, is 94 feet deep; No. 2, 285 feet; No. 3, 293 feet; No. 4, 282 feet 6 inches; No. 5, 250 feet; No. 6, 230 feet; and No. 7, 125 feet. Besides these, there are the following intermediate shafts, No. 8, No. 1 *a*, No. 4 *a*, and No. 5 *a*. All are permanent shafts but No. 1 and No. 8. The shafts are generally 25 feet in diameter; where built of masonry, 2 feet in thickness, and where of brickwork, 1 foot 10½ inches. Shafts Nos. 1 *a*, 4 *a*, and 5 *a*, are each 12 feet 6 inches square.

The strata consist of forest marble, great oolite, fuller's earth, inferior oolite, and lias marl. At shaft No. 6 the inclination of the strata is 1 in 32.

From No. 3 shaft to No. 5 shaft, and also at No. 8 shaft, the strata are nearly in a horizontal position.

The bricks used in this tunnel are from Chippenham, and cost 41*s.* 6*d.* per thousand. The brickwork in mortar is estimated at 42*s.* per cubic yard, and in cement at 47*s.*; this includes the excavation for brickwork. Ashes from Trowbridge form a component in the mortar. The cement used is from the works of Bailey and White, London; it is mixed with sand in equal proportions.

The total quantity of excavation in this tunnel is 247,000 cubic yards; of this 174,000 consists of freestone and marl, and the remainder of freestone. The average depth of excavation is 35 feet. The excavation in freestone is estimated at 9*s.* per cubic yard, and in marl and freestone at 10*s.* 6*d.* The labour to freestone costs at the rate of 3*s.* per cubic yard; and to brickwork 8*s.* 6*d.*, including mortar and lowering the materials.

On December 13, 1839, when we visited this great work, a length of 5241 feet was finished. On the 24th of February following, Mr. Brunel reported that 5700 feet were excavated; so that the progress in this interval of time was about 6 feet per day.

Ten miners are employed at each heading, and six fillers; altogether about 500 men night and day. The miners' wages are from 5*s.* to 6*s.* a day; bricklayers 6*s.*; labourers 3*s.* 6*d.* In freestone the miners have reduced wages, viz. 3*s.* 6*d.* to 4*s.*, and the labourers 3*s.* a day respectively.

Shafts Nos. 6, 7, and 8 are worked by steam-engines, and the other shafts by horse-gins; each shaft having two gins driven by three horses, one brakesman, and two tippers. At shaft No. 6 there are two steam-engines, the one of 6-horse power for raising and lowering the materials; the other of 30-horse power, for pumping the water from the tunnel. The pumps are each of 18 inches in diameter. At No. 7 shaft there are three engines; two for the same purposes as above, and the third purposely for raising stone. Not less than 30 tons of coal are used per week for these engines, at a cost of 26*s.* per ton. At No. 8 shaft there is one engine of 8-horse power, to work two 8-inch pumps, and for raising and lowering materials.

In blasting the stone Bickford's patent fuse has been used to a considerable extent, and only one accident was reported to have happened in consequence of its use up to December 1839. The cost of blasting freestone

Mr. Yockney reckons at about $5\cdot87d.$ per cubic yard. In red sandstone $2\frac{1}{2}$ lbs. of powder are used, while in freestone only 1 lb. is required, per cubic yard.

Mr. Burge is the principal contractor for this stupendous work, and Mr. Glennie the resident engineer; under whom are Messrs. Shireff, Marchant, Murray, Blatchley, Orton, and Paxton.

At shaft No. 8 we met with a very intelligent person in Mr. Yockney, who represented Messrs. Leeds and Brewer, contractors for shafts Nos. 7 and 8.

The width of land enclosed for the tunnel is 30 feet; when the work is completed, the land will be returned to the proprietors, subject to a right of way to the shafts.

In connexion with the Box tunnel must be mentioned the contiguous cutting on the east side, the contents of which amount to 1,533,000 cubic yards, of corn-brash, forest-marble, and great oolite; the length being about $2\frac{1}{2}$ miles, the average depth about 30 feet, and the slopes from vertical to $1\frac{1}{2}$ to 1.

Besides the Box tunnel, there are seven others, situate between Box and Bristol. Commencing at the Bristol end, the first tunnel is 990 feet long, 30 feet wide, and 35 feet high at each entrance, the general height being 30 feet; the greatest depth from surface of ground to level of rails is 76 feet. The west front is in the Norman style of architecture, and presents a bold and pleasing outline. This work was commenced in April 1836, and the excavation was finished in November 1837.

No. 2, or the ivy-mantled tunnel, is the same in cross section as No. 1, but in plan it is slightly curved; its length is 475 feet, the greatest depth from surface of ground to top level of rails is 99 feet 6 inches. The western face represents the entrance to an old ivy-mantled castle, and is the first, and we may say perfectly successful attempt in railway-works so to blend nature and art as to produce the most pleasing effect on the mind of the spectator. We are far from advocating useless expenditure in architectural adornments to railway-works in general; but there are situations in which it is perfectly justifiable. Within an easy walk of Bristol, the ivy-mantled tunnel will, no doubt, long be considered one of the principal attractions of the neighbourhood.

No. 3, or the Brislington tunnel, is 3148 feet in length, and of the same transverse section as Nos. 1 and 2, but at the eastern entrance the stone is

hewn out to the height of 40 feet: the strata intersected by this tunnel are coal-measures, shale, and Pennant sandstone. In sinking some of the shafts, slight interruptions were caused by meeting with old coal-workings. The shafts are each of 9 feet diameter, and four in number; the brickwork being 14 inches in thickness. No. 3 is the deepest shaft, being 116 feet 6 inches from the surface of the ground to the rails.

No. 4, or the Saltford tunnel, is 499 feet 11 inches long, 30 feet wide, and 32 feet 6 inches high. The arch is segmental, described from a radius of 30 feet, and having a versed sine of 13 feet.

No. 5, or the Twiverton tunnel, which is carried through red marl, is arched throughout, and is 767 feet 6 inches in length. The arch is of Gothic form, and the fronts are castellated. In connexion with this tunnel is a retaining wall, 1120 feet in length and 49 feet high.

Besides the above there is a short tunnel through Middle Hill, west of the Box tunnel; and an archway east of Brislington tunnel, which is 111 feet long, 30 feet wide, and 30 feet high.

VIADUCTS AND BRIDGES.—Among the principal bridges and viaducts may be mentioned the Wharncliffe viaduct at Hanwell, the bridge over the Thames at Maidenhead, and the Bath viaduct.

The Wharncliffe viaduct, which carries the railway over the valley of the Brent at Hanwell, is constructed of brickwork, with stone imposts, cornices, and copings. It consists of eight semi-elliptical arches, each of 70 feet span, and rising 19 feet. The arches are constructed in rings, and are 36 inches thick at the crown, increasing gradually to nearly double this thickness at the haunches. Four intermediate spandril-walls, two bricks in thickness, are built over each arch, and are 7 feet from middle to middle, serving as foundations for the longitudinal timbers and rails. The piers are built in hollow panels, and average 13 feet in thickness; the height from the ground-level to the springing line of arches being $40\frac{1}{2}$ feet. There are several courses of footings to the piers, amounting to 10 feet in thickness, which extend 9 feet beyond the face of each pier all round. The whole length of this structure is about 886 feet, the whole height from bottom of foundation to top of parapet 81 feet, the clear width between parapets 30 feet, and each parapet is 18 inches in thickness. The wing-walls are $6\frac{1}{2}$ feet in thick-

ness at bottom, and built with a batter of 1 in 10; the base of the footings is 18 feet in width, and the depth of footings 8 feet 6 inches. The design is altogether elegantly chaste; and this viaduct may, upon the whole, be considered one of the finest features of this great undertaking.

Next in order we may slightly describe the bridge over the Thames at Maidenhead, which has been the source of so much jealous feeling and hateful misrepresentation; but which is now securely fixed, and stands perfectly free of its centres.

This bridge is also constructed chiefly of brick, and consists altogether of ten arches, two of which are over the river, and are each of the extraordinary span for brickwork of 128 feet, while the rise or versed sine is only 24 feet 3 inches, the form being semi-elliptical. The arches are built of brick rings, amounting in thickness at the crown to 63 inches, and at the haunches to 85 inches. The land-arches, which are uniformly disposed on either side of the river-arches, are semicircular; those nearest the river, or the abutment-arches, being each of 21 feet, and the others each of 28 feet span. The central, or river-pier, is 30 feet in thickness, and 20 feet high from the lowest line of foundation to level of springing line of arches, and is built solid throughout, while the land-piers are built hollow; the whole thickness of each being 10 feet. The intermediate spandril-walls over the river-arches are six in number. There is a considerable depth of concrete over the land-arches, extending to within a foot of the rails over the abutment-arches, and to within about $5\frac{1}{2}$ feet of the same level over the remaining land-arches. The whole length of this bridge is 768 feet; the height, from lowest line of foundation to top of parapet, 56 feet 2 inches; the clear width between parapets 30 feet; and the parapets each $13\frac{1}{2}$ inches in thickness.

To our view, a bridge with three river-arches, in place of two, would have presented a far more sightly appearance; but in such a case the design should be regulated by cost, as it is not a single bridge, but a great number of bridges, which are required for a railway.

The Bath viaduct extends to a length of 306 feet $4\frac{1}{2}$ inches, and consists of sixty-five segmental arches, varying in span from 19 feet 6 inches to 20 feet $5\frac{1}{2}$ inches. The arches, which with the rest of the structure are of Bath stone, are 3 feet thick at the springing, and 2 feet at the crown. The piers are 2 feet 10 inches in thickness; the clear width between parapets is

30 feet; and each parapet is one foot in thickness. The whole is of chaste and beautiful design, and is quite in keeping with the architecture of the celebrated city of Bath.

Near to this viaduct is the bridge over the river Avon, which is constructed of wooden framing resting on stone piers. It consists of two openings, each of 89 feet, and rising 16 feet 9 inches; the height from the level of water to that of rails is 36 feet. The railway forms an angle with the direction of the stream of about 28°.

The Twiverton viaduct is 245 feet long, and consists of nine arches, seven being of 15 feet, and two of 24-feet span each, and 14 feet 6 inches high. Eleven houses are fitted up under the arches, with two rooms in each; these are let to Mr. Wilkins for the use of his workmen.

The bridges over the railway are of 30 feet span, and about 18 feet 6 inches high; and the general clear width between parapets of bridges carrying the railway over roads, &c. is 30 feet.

GAUGE OF WAY, &c.—The gauge of way is 7 feet, the intermediate space 6 feet 6 inches, and the side-spaces on embankments each 4 feet 9 inches, making the total width 30 feet.

The rails used are entirely of the bridge-form (see Plate III. figs. 18 to 25 inclusive), weighing from 44 lbs. to 62 lbs. per yard lineal. The 44 lbs. rails are, however, found to be too light for the heavy trains which pass over them.

The plan originally designed by Mr. Brunel for laying the permanent way has been carried into execution only as far as Maidenhead, being found to possess no advantages equivalent to the greatly increased cost incurred by its adoption. The peculiar feature of this plan is the introduction of piles, driven in pairs down the whole length of the way, at intervals of five yards; one pile between each pair of rails being placed rather closer to the outer than the inner rails. These piles are of beech, about 10 inches diameter, and 12 feet in length. The piles are held together by cross ties of American white pine, let into a groove cut out near the top of each pile, and firmly bolted thereto. Every alternate pair of piles has two cross ties, secured in the same manner; the top of each pile is about level with the surface of the ballasting.

On the transverse ties are laid longitudinal sleepers, also of American white pine, 15 inches wide by 7 inches deep; each pair being 5 feet $11\frac{1}{2}$ inches apart, or 7 feet $2\frac{1}{2}$ inches from middle to middle. These sleepers are firmly secured to the cross ties by stout screw-bolts and nuts. On the top of the sleepers is firmly secured $1\frac{1}{2}$ -inch elm planking, 8 inches wide; between which and the sleepers is a layer of good Stockholm tar.

The rails are fastened down to the planking by screw-bolts passing through perforations made in the flanches of rail, a thickness of felt being introduced between the rails and the planking.

The screws are supplied to a great extent by Mr. Ryland, of Birmingham, whose apparatus for preparing them is of the most ingenious description, requiring but the attention of one person until the whole process is completed. The screws necessary for the whole line from London to Bristol, we were informed, would cost something like 20,000*l*.

The whole of the timbers as far as Maidenhead have been kyanized; and the exposed surface of the sleepers and ties, as well as the bolts, screws, and other iron-work, coated with tar. Beyond Maidenhead, for the rest of the line, cross timbers are introduced between, and the ends dove-tailed into the longitudinal timbers, and firmly secured thereto with screw-bolts and nuts.

The longitudinal timbers are 12 inches by 6 inches; and the cross timbers, of which there are three to each length, or baulk, 6 inches by 4 inches. The cubical contents of the longitudinal timbers for the main double way between London and Bristol amount to about 1,348,644 feet, or 26,972 loads; by altering the scantling of these timbers from 15×12 to 12×6 , a saving is effected of about 9188 loads.

The ballasting is chiefly of gravel, 18 inches in thickness.

The fencing consists of posts and three rails in the London division; and in some cases a wire is introduced between the two lower rails. In the Bristol division four rails are used. The drainage appears to be complete throughout.

The width of land enclosed for the railway, exclusive of slopes, but including 15 feet on each side for hedge and ditch, is 64 feet 6 inches. The whole area of land enclosed for the railway, according to Mr. Saunders' evidence as above, is at the rate of 12 acres per mile; this gives for the

whole line 1408·848 acres. Up to the 30th June, 1840, the cost of lands and compensations, including valuer's charges, was 718,068*l.*, which is at the rate of upwards of 500*l.* an acre.

The mile-standards are of wood, and are placed at intervals of a quarter of a mile on the up side of the line.

STATIONS AND DEPÔTS.—Besides the terminal stations at London and Bristol, there are at present the following intermediate stations open to the public, viz. Ealing, Hanwell, Southall, Drayton, Slough, Maidenhead, Twyford, Reading, Pangbourn, Goring, Moulsoford, Steventon, Faringdon Road, and Bath; and there will, no doubt, when the line is completed throughout, be stations at Swindon, Wootton Bassett, Chippenham, and Box.

The London station and depôt are at present in an unfinished state; the sheds and locomotive engine-house are constructed of wood. The station at Bristol is raised on rough stone arches; but on our visit to this part of the line in December 1839, it was not sufficiently advanced to afford us an opportunity of witnessing the arrangements. The intermediate stations generally are not built in a costly style, yet are conveniently arranged, if we except the too great distance at which some of the platforms are removed from the main line of way.

The Bath station occupies an area of 13,500 superficial feet, and is about 30 feet above the general surface of the ground. It is approached by a sloped road from Pierpoint Street.

CARRIAGE DEPARTMENT.—The carriages in use on this railway are shewn in plan and elevation in Plates X. and XI., and consist of posting-carriages, large first-class, small first-class, large second-class, and small second-class carriages; carriage-trucks; horse-boxes, large wagons and small wagons, and sheep-trucks. When the line was first opened, there was another description of carriage in use, viz. closed second-class; but being found to detract from the traffic by the first-class carriages, was speedily abandoned.

The posting-carriage, which is calculated to hold eighteen persons, is fitted up in a style of elegance not met with in any other railway-conveyance in the kingdom (save only the royal railway-carriage): it is furnished with cushioned seats all round except at the doorways, and a table extending down

the middle, so that for a family party or party of friends it is a most excellent contrivance. The whole length of the body is 18 feet 6 inches, and on a level with the seats 18 feet; the width of body is 7 feet 6 inches, and below the same level it is diminished in a recurving line to 6 feet at bottom, the height of body being 6 feet 8 inches. In the middle of each side there is a glass-door 2 feet 4 inches wide and 6 feet high, the glass-square being 19 inches high and 21 inches wide; affixed to the sole of the carriage, and furnished with two steps, is an iron-tree, the bottom of which is 14 inches above the rails. On each side of the door there are two lights ranging in height with that of the door, and above these are three smaller lights, which fill up the whole of the top spaces between the door and the ends of the body.

The under carriage is formed of two soles, 7 feet 8 inches apart, 9 inches deep, and 4 inches thick, and projects 10 inches at each end beyond the body; and six cross pieces, one at each end without the line of the body, which are 15 inches deep and 4 inches wide; and the others arranged one before and the other behind each pair of wheels, and equidistant from the centres of axles. The two ends of each of these cross pieces are finished with ornamented scrolls, and project six inches beyond the outer side of each sole. The diagonal braces, which are of $1\frac{1}{4}$ -inch iron, run from each angle of the carriage towards the centre of frame; the carriage is furnished with complete buffing and traction-apparatus (see Plate XI.), and is mounted on four of Losh's wheels, 4 feet in diameter, and 10 feet from centre to centre of axles. The bow-springs are each 5 feet 4 inches in extreme length, the bed of each being 6 inches below the centre line of wheels. The weight of a posting-carriage is 11,856 lbs.

The large first-class carriages, which are mounted on six wheels of 4 feet in diameter, and 7 feet from centre to centre of axles, are in four compartments, each calculated to hold eight persons, or thirty-two in all; some of these compartments are subdivided by a central partition, in the middle of which is a glass door furnished with a roller-spring blind. This arrangement is found to be attended oftentimes with considerable advantage, in affording ladies and small families the means of travelling, as it were, alone. The fittings of the interior are of the most comfortable description, including the stuffed leather cushions, elbows, and linings, added to the additional height given to all the Great Western carriages. Each compartment has side-lights

ranging with the sashes of the doors; and above these lights, and corresponding in width, are as many shallow blinds. The length of a large first-class carriage-body is 24 feet, the width 9 feet 6 inches, and the height 6 feet. The floor of the carriage is 3 feet 7 inches above the level of the rails; the extreme length from face to face of the buffers is 26 feet 2 inches.

The under frame is generally on the same plan as that of the post-ing-carriage, except that the diagonal braces are of wood, and are eight instead of four in number. There are three steps to each doorway, the lower two being fixed to an iron-tree, and the upper one to the sole of the under carriage. The distance from centre to centre of buffers is 5 feet 10 inches. The weight of a large first-class carriage is 15,232 lbs.

The small first-class carriages are mounted on four wheels, and are divided into three compartments, each having seats for eight persons, or 24 in all. The weight of this description of carriage is 10,528 lbs., and the length of the body is 18 feet. The general plan and arrangement is similar to that of the large first-class carriage, except as to the number of wheels, and the difference in length.

The large second-class carriage is open at the sides, and is divided into six compartments, each calculated to hold twelve persons, or seventy-two in all. The clear width of each compartment is 8 feet 7½ inches, and the clear length 4 feet 4½ inches; each seat is 15 inches in width. The whole length of the body is 27 feet 2½ inches, the width 9 feet, and the height 6 feet. The width of each door is 18 inches, and the height 2 feet 8 inches. The whole of the sides are in square panels, including the doors. The wheels are six in number, and each of 4 feet diameter; the distance between centre and centre of axles being 9 feet. The under frame is somewhat similar to that of the first-class carriage, except that it has an ordinary draw-bar instead of the improved traction-apparatus, and is furnished with a Stanhope lever-brake, having clutches for two wheels. The weight of a large second-class carriage is 12,712 lbs.

The small second-class carriage is divided into four compartments, each calculated to hold twelve persons, or forty-eight in all. It has four wheels, is 18 feet in length, and weighs 8614 lbs. In other respects it is the same as the large first-class carriage.

Taking the several passenger-carriages at their respective weights as above, and the passengers and luggage, on an average, at 170 lbs. each, we find that the proportion of dead weight to profitable weight is as 1·78 to 1, supposing each carriage to contain its full complement; but, taken separately, the proportion of dead to profitable weight in each kind of carriage is as follows, viz. in the posting-carriage 3·87 to 1; in the large first-class 2·80 to 1; in the small first-class 2·98 to 1; in the large second-class 1·038 to 1; and in the small second-class 1·055 to 1. Thus the gross weight for each first-class passenger may be taken at 646 lbs., and for each second-class passenger at only 346 lbs.; while the charge for the conveyance of first-class passengers is at the rate of 9·963*d.*, and of second-class passengers 11·33*d.* per gross ton per mile.

The carriage-trucks used on this line are each mounted on four of Losh's wheels, of 4 feet diameter, and 8½ feet from centre to centre of axles; but having the ordinary springs 3 feet 4 inches from point to point, the bed being 4 inches above the centre-line of axle: this carriage is furnished with a Stanhope lever-brake. The length of the body is 15 feet 4 inches, the width 6 feet 8 inches, and the height of each side 14 inches; the weight of a carriage-truck is 7442 lbs.

The horse-boxes are each of a size sufficient for four horses; and are mounted on two pair of common wheels of 3 feet diameter, and 6 feet from centre to centre of axles. On one side a proper ledged flap, the whole length of box and 3 feet 6 inches wide, is hung on the upper part of sole, with stout hinges 3 feet 5 inches in length, and 2 inches wide. Above this longitudinal flap are folding-doors, which are hung to the corner-posts with two stout hinges. The flaps and doors are provided with strong iron fastenings. When horses are to be admitted into or led out of the box, the flap is let down on to the station-wharf, and the doors are thrown open. The length of a horse-box is 9 feet 8 inches, and extreme length from the face of one buffer to that of the other 12 feet 8 inches; the width 8 feet 10 inches, and the height 7 feet 6 inches. The floor of the box is 3 feet 4 inches above the level of the rails. The springs are of the ordinary construction, and 2 feet 10 inches from point to point. The weight of a horse-box is 9632 lbs.

The small wagon is mounted on four of Losh's wheels, of 4 feet diameter, the distance between centre and centre of axles being 9 feet 9 inches.

The springs are of ordinary form, 3 feet from point to point, but are bedded below the journals, the bed being 7 inches below the centre-line of axle. The centre-line of buffer is 3 feet 1 inch above the level of rails; and the bottom of wagon is 3 feet 8 inches above the same level. The length of a small wagon in the clear is 17 feet, the clear width at bottom 8 feet 1 inch, and at top 8 feet 3 inches; the sides are 2 feet 8 inches, or three boards high. The sides and ends are 2 inches thick, and also the floor. The sides are secured with proper bolts and screws to stout oak cut stays, or struts, 3 inches wide and 3 inches thick. These stays rest on the ends of the joists, or cross timbers, which project $6\frac{1}{2}$ inches beyond the face of the sole of the under carriage. Each end is fixed to proper ledges, and hung with strong hinges, so as to let down at pleasure. There is also a ledged flap in the middle of each side, 4 feet 7 inches wide, and corresponding in height with the wagon; each flap is hung to a plate, or hanging stile, 3 inches deep, which runs along the top of the sole and between the joists. The bottom of the wagon is 3 feet 8 inches above the level of the rails. The under carriage, or frame, consists of two soles, each 18 feet 6 inches in length, 8 inches deep, and 5 inches wide, being 8 feet apart; and four transverse pieces, or joists, each 10 feet long; that at each end being 9 inches by 5 inches in substance, and the intermediate joists 8 inches by 5 inches, and 4 feet 10 inches apart. There are six diagonal braces, each 7 inches by 4 inches; two of which run from the opposite angles of the middle part of the frame, crossing each other at the centre; and the others from the end-joists to the nearest intermediate joist. These latter are connected together by angle-plates, which are secured to the diagonal braces, end-joists, and soles, with screw-bolts and nuts, and at the other end to the nearest intermediate joist, also with screw-bolt ties and nuts. The draw-bar is in two parts, each of which runs through the end-joist and nearest intermediate joist, and terminates with a spiral spring 14 inches beyond the inside of the intermediate joist. Solid buffers, covered with leather, are attached to the end cross joists, which are 12 inches in diameter, and project as much beyond the face of the joists. Two stout four-linked chains are attached to each end of the different carriages, besides the draw-chain. The weight of a small wagon, as above described, is 7105 lbs., including the wheels.

The large wagons have six wheels, and are of greater length; but with

regard to general arrangement and construction, they are similar to the small wagon as above described. The weight of a six-wheeled wagon is 10,262 lbs.

The sheep-trucks are furnished with high sides, have each four wheels, and weigh 8237 lbs.

The coke-wagons are mounted on six wheels, and will each hold from 150 to 200 bags of coke.

The turn-tables for four-wheeled carriages and trucks are 13 feet in diameter.

OPENINGS OF DIFFERENT PORTIONS OF THE LINE.—This line was first opened to the public on the 4th June, 1838, as far as Maidenhead, a distance of $22\frac{1}{2}$ miles from London. On the 1st July of the following year, it was further opened to Twyford station, $30\frac{1}{2}$ miles from London. In March 1840, another portion was opened as far as Reading; in June, it was extended to Steventon; and now it is opened to the Faringdon Road, a distance of $63\frac{1}{2}$ miles from London.

The opening of that portion of the line between Bath and Bristol took place on the 31st August last, so that the public have now the use of about 75 miles of this railway; and the whole line Mr. Brunel expects will be finished about August 1841.

TRAINS, &c.—We found the average gross weight of twenty-five passenger-trains to amount to 76,346 lbs.; the average velocity to be 25·43 miles per hour; and the stoppages to occupy on an average 1·568 minutes (see Table F. of Practical Experiments, in Appendix).

When the line was first opened to the public, the number of trains daily in each direction between London and Maidenhead was eight, except on Sundays, when there were only six. Thus the Company's engines, with passenger-trains, ran 2430 miles per week, or at the rate of 126,360 miles per annum.

In October 1839, the line being opened as far as Twyford, there were ten through-trains daily in each direction, one to and from Maidenhead, and three short trains to and from West Drayton, except on Sundays, when there were four through-trains in each direction, four down to Maidenhead, and three up, and one up from West Drayton. Thus the number

of miles per week, at that time, was more than doubled, being 5,114·50, or at the rate of 265,954 miles per annum; and at the present time (the line being opened to the Faringdon Road, a distance from London of 63½ miles), there are ten through-trains daily in each direction, including one mail and two goods-trains, except on Saturdays, when there is only one up. There are also two trains to and from Reading; three trains to and from Maidenhead; and four trains to and from Slough. On Sundays there are four down trains to Steventon, and five up; two in each direction between London and Reading, one to and from Maidenhead, and three in each direction between London and Slough. Thus the number of miles travelled by the Company's engines weekly amounts to 10,958·50, or at the rate of 569,842 miles per annum.

The number of persons who travelled on this line from the opening on the 4th June, to 31st December, 1838, amounted to 270,892, which is, on an average, about 1331 per diem. Again, from June 4th, 1838, to 31st March, 1839, inclusive, the number was 355,889, or, on an average, at the rate of about 1177 per diem; and from the 4th June, 1838, to 31st January, 1840 (excluding the month of April 1839), the total number of passengers on this line amounted to 865,040, or, on an average, at the rate of nearly 1500 per diem.

The proportion of second to first-class passengers, during the first ten months of this line being opened, was as 3·75 to 1.

The fares for first-class passengers are at the rate of 2·875*d.*, and for second-class passengers 1·75*d.* per mile. The tickets are taken from passengers as they enter the carriages. The charge for goods is about 3*d.* per ton per mile.

LOCOMOTIVE ENGINES.—The locomotive engines used on the Great Western Railway are chiefly from the works of Messrs. Robert Stephenson and Co., Messrs. R. and W. Hawthorn, Messrs. Tayleur and Co., Messrs. Sharp, Roberts, and Co., and Messrs. Mather, Dixon, and Co.; but there are also engines from other works, as will be seen by reference to the Table No. VIII. of British Locomotive Engines, in the Appendix. We have not been able, however, to tabulate more than thirty-nine engines altogether, the proportions of which will be seen in the table above referred to. With the

exception of the Hurricane and Thunderer, which are built on Mr. T. E. Harrison's patent principle, the whole are six-wheeled engines. The usual pressure of steam is from 50 to 55 lbs. on the square inch. (See Plate I.)

In the twenty-five practical experiments which we made on this line in 1838, 1839, and 1840, the whole distance gone over amounted to 540·50 miles; the highest velocity we found to be 50 miles an hour, the lowest 4·28 miles, and the average velocity 25·43 miles per hour. In six of the experiments we reached 50 miles; and in thirteen the highest rate of velocity was from 35 to 48 miles an hour. On the 4th June, 1838, the day of opening the line to the public, the nine o'clock down train, drawn by the *Æolus*, averaged only 15·56 miles an hour, with a load of 80,078 lbs.; and the same engine, on the 21st July following, with a load of 96,194 lbs., occupied 115·25 minutes while in motion between London and Maidenhead, 22·50 miles, being at the rate of only 11·71 miles an hour. From that time, however, up to 7th March of the present year, the average speed had increased to about 30 miles an hour. We fully anticipate the quick trains making the journey throughout to Bristol in four hours. The engines cost from 1850*l.* to 2150*l.*; and the net weight varies from 15 to 19 tons.* The average weight of twenty-five trains we found to be about 34 tons gross.

In thirteen weeks, including July, August, and September, 1839, the quantity of coke consumed amounted to 3,323,376 lbs., or at the rate of 5939·06 tons per annum; the miles run by the Company's engines in the same time being 68,164, exclusive of piloting and assisting, which amounted to 2755 miles.

The coke-ovens are situate at West Drayton, about half a mile to the east of the station; and are very similar to those of the north of England and Scotland, being without a lofty chimney, which adds so greatly to the cost. They are conveniently placed on the level of the railway, which saves much labour in filling the wagons. On the London and Birmingham and South Western lines, the ovens are at a considerable depth below the railway. Where it can be managed, the coke-stage should be on a level with the wagons, so that they may be loaded with the greatest facility.

* In Table No. VIII. the *Morning Star* is set down at only 12 tons 12 cwt. This we find to be copied from Messrs. R. Stephenson and Co.'s own list, obligingly lent to us.

ANNUAL CHARGES.—From the 4th June, 1838, to the 30th June, 1840—

The receipts for passengers, parcels, merchandise, and carriage of	} £ 243,159 12 3
timber and materials for the line, amounted to	
And the expenditure for the same period to	126,117 19 3
Leaving a balance of	<u>£ 117,041 13 0</u>

Thus the cost of maintenance of way, locomotive power, repairs of engines and carriages, salaries, &c., amount together to 51·87% per cent on the gross revenue.

The different items of expenditure are—

Maintenance of way, which amounted to	£ 19,978 3 9
Locomotive account	47,324 17 2
Carrying account	27,031 18 1
Repairs to, and alterations of stations	454 16 7
Compensation, returns and allowances	1,030 14 4
Government duty	12,417 15 0
Rates and taxes	3,687 5 9
General charges, including superintendents' and clerks' salaries, } advertising, printing, stationery, and travelling expenses . }	14,192 8 7
	<u>£ 126,117 19 3</u>

The following exhibits the various items of expenditure from the commencement of the undertaking to 30th June, 1840:—

Expenses before the Act to 24th October, 1835	£ 89,197 11 3
Parliamentary expenses	29,104 5 4
Lands and compensations	£ 704,959 19 8
Valuers' purchasing lands	13,108 0 11
Freehold premises in Princes Street, City	19,600 4 5
	<u>737,668 5 0</u>
Engineering, including Mr. Brunel's salary and travelling expenses	} 117,081 0 0
—Assistant engineers' salaries—Sub-assistants' salaries—Travelling expenses—Draftsmen's salaries—Overlookers of works	
—Drawing-paper, book-binding, printing, and stationery, for engineer's offices—Lithographing parliamentary plans, &c.—	
Mr. Hennet, for surveying, &c. . . .	
Engraved map of Great Western Railway	
Experiments made by Mr. Wood and Mr. Hawkshaw	3,201 11 9

HULL AND SELBY RAILWAY.

Law-charges, conveyancing, and costs of titles, &c. . . .	43,958	16	9
Contracts for works and stations	£2,484,541	11	11
Permanent way, timber-contract, iron rails, screws, felt, and other materials, drain-tiles, tanks, tools, lighterage, cartage, and labour }	635,275	0	0
			3,119,816 11 11
Locomotive engines, carriages, trucks, horse-boxes, &c. . . .	222,995	4	3
Office-expenses, direction, &c.	35,592	15	6
Advertisements, printing, &c.	2,810	9	10
Travelling expenses, &c.	3,562	12	0
tamps for debentures	9,262	9	0
Balance of interest paid on loans	93,307	6	0
			144,535 12 4
			£4,508,160 3 4

HULL AND SELBY RAILWAY.

THE great northern transverse chain of railway-communication between the Irish Sea and the German Ocean requires but one very short link to render it complete. This we need scarcely say is at Manchester, where, for want of a junction between the Liverpool and Manchester and Manchester and Leeds railways, the chain may be said to be as yet broken. This desirable, though yet incomplete communication, is effected by means of the following lines, viz. the Liverpool and Manchester, the Manchester and Leeds, the York and North Midland, the Leeds and Selby, and the Hull and Selby railways.

Many years ago, a railway was proposed between Leeds and Hull, but it was not until 1831 that the Leeds and Selby line, forming one portion of this project, was carried into execution. The remaining length was, however, soon taken up, chiefly by the merchants and residents of Hull, who applied to Messrs. Walker and Burges to prepare plans and an estimate for a railway between Hull and Selby, which would render the Leeds and Hull junction complete. An accurate survey was accordingly made under their direction by Mr. Comrie, an eminent surveyor of London; and in July 1834,

a report from the engineers was made to the subscribers for the survey, which set forth the favourable nature of the country, the entire absence of buildings except at the termini, the great proportion of the line entirely free from curves, and the easy gradients to be obtained throughout. Although to first appearance a completely level railway might be obtained in a fen country, or over marsh lands, yet in many cases a slightly undulating district, as regards gradients and materials for the works, is to be preferred. An illustration occurs to us at once, in the case of the line between Crewe and Birkenhead, a distance of $35\frac{1}{2}$ miles, in which there is no gradient in the main line exceeding 16 feet, whereas in the Hull and Selby there are gradients of 22 feet and 19 feet respectively; and in the one case materials for ballasting and building have been readily obtained, while in the other they have been led from a considerable distance.

The Hull and Selby Railway Company obtained their Act of incorporation in the session of 1836, the royal assent being given to it on the 21st June of that year. By this Act the Company were empowered to raise a joint-stock capital of 400,000*l.* in 8000 shares of 50*l.* each, and by loan 133,333*l.* additional, making a total of 533,333*l.*

COURSE OF THE LINE.—Leaving the Leeds and Selby Railway on the south side of the Ouse, the line crosses that river by a handsome bridge of one arch, about 200 yards below the Selby bridge; and with a curve of about half a mile radius, falls into a direction a little to the south of east, and continues in a direct line for about 18 miles, passing in its course the villages of Cliff, Wressel, and Eastrington, and crossing over the river Derwent and the Market Weighton Canal. From Brough the line continues for about a mile in the same direct line, and thence, slightly curving, passes between North Ferriby and the river Humber, south of Hesslewood House, through Hessle Cliff; and thence, keeping close to the foreshore, reaches its eastern terminus on the West Quay of the Humber Dock at Hull, the whole distance being 30·65 miles.

GRADIENTS.—Instead of a level line, the Hull and Selby is a completely undulating railway passing through a level country. The gradients, however, are generally within the first class, and there are four level planes amounting

in length to 9·63 miles. The introduction of second-class gradients is caused by the necessity of passing over the rivers Ouse and Derwent at considerable elevations above the water's surface. The number of ascending planes, according to Bradshaw's Book of Levels,* between Selby and Hull is twelve having inclinations varying from 1 in 278 to 1 in 3916, and amounting in length to 12 miles 34 chains; and the number of descending planes nine, varying in inclination from 1 in 240 to 1 in 1320, the collective length of which is 8 miles 34 chains.

BRIDGES, &c. — The principal bridges are over the rivers Ouse and Derwent, and the Market Weighton Canal: that over the Ouse, which is the principal work on the line, is an opening balance-bridge for the purpose of admitting vessels up as high as the Quay at Selby, and is among the few instances of bridges of this description being used for railways. The arch over the Derwent, and also that over the Market Weighton Canal, are both of cast iron.

The whole railway is carried chiefly on embankments formed partly from side dykes. The principal cuttings are at North Ferriby and Hessle, from the latter of which have been removed about 230,000 cubic yards chiefly of rock and gravel, which materials have been partially used for ballasting the way. The embankment next the foreshore at Hull, nearly a mile in extent, is protected on the river side by the slope being paved with stone on its whole surface. This work appears to be done in a most effectual manner.

GAUGE OF WAY, &c. — The gauge is necessarily 4 feet 8½ inches, as this line is a collateral link of one of the great chains of communication from the metropolis to the north by the Birmingham and North Midland Railways; and is also the eastern terminal link of the Liverpool and Hull transverse line.

There is an entire absence of stone blocks on this railway, two-thirds of the whole length being laid with longitudinal, and the remainder with cross sleepers, the whole of which are kyanized. The longitudinal bearers are of Baltic half timbers, and are connected by cross sleepers.

* By reference to page 16 of this book, there will be found four discrepancies in the intermediate distances inserted in the table relating to this line, taking the total distance at 30 miles 51 chains.

The rails are of somewhat similar form to those used on the Croydon and North Shields railways (see Plate III. figs. 27 and 28, and also figs. 40 and 50). They are of two sizes; those for the longitudinal bearers weighing 55 lbs., and those for the cross sleepers 63 lbs. to the yard lineal; the former are $2\frac{1}{2}$ inches, and the latter $3\frac{1}{2}$ inches in depth. The shallow rails are set in saddles 12 inches long, 5 inches wide, and $2\frac{1}{4}$ inches in extreme depth, weighing each 22 lbs. In the base-plate on each side of the socket are two $\frac{1}{2}$ -inch apertures for the spikes or bolts with which they are secured to the timbers.

The rails used with the cross sleepers are set in chairs 12 inches by 5 inches, and $3\frac{1}{2}$ inches in extreme depth: these also have four $\frac{1}{2}$ -inch holes in the base-plate. In both cases the rails are secured to each chair with a pair of oak cut and compressed keys, 7 inches long, which render the movement of the rail almost impossible.

The rails were severally furnished by Messrs. Guest and Co., Mr. Crawshay, and the Rhymney Iron Company.

STATIONS. — Besides the terminal, there are eight intermediate stations, which are situate respectively at Cliff, 2·65 miles from Selby; Howden, 8·65 miles; Eastrington, 11·65 miles; Staddlethorpe Broad Lane, 14·65 miles; Brough, 20·65 miles; Ferriby, 23·65 miles; and Hessle, 26·65 miles.

The buildings at the Hull station and dépôt, which are near the Humber Dock, comprise the booking-office, secretary's office, engine-house, smith's shop, and large warehouse. There are several lines of way at this station.

CARRIAGES AND LOCOMOTIVE ENGINES.—The stock of passenger-carriages consists of ten first-class carriages, built on the usual plan of construction in three compartments; twenty second-class carriages, the former costing 440*l.*, and the latter 195*l.* each; and six third-class carriages. The goods-wagons are fifty in number, the cost of each being 60*l.* Messrs. Hustwick and Bean, of Hull, from whose establishment the carriages are furnished, appear to have bestowed considerable pains in the construction and finishing, especially of the first-class carriages.

The stock of locomotive engines consists of twelve six-wheeled machines, built by Messrs. Fenton, Murray, and Jackson, of Leeds. We are unable to give their proportions; nor have we hitherto had an opportunity of testing their capabilities.

Besides the water-station at either end of the line, an intermediate one has also been formed at Staddlethorpe Broad Lane, 14·65 miles from Hull, being nearly half way between the termini. At this place there is a reservoir, which will contain about a million and a quarter gallons of water. A small pumping-engine has been erected at this place.

TRAINS AND FARES, &c.—The trains at present run from either terminus five times daily. The fares, are for first-class passengers, 4*s.* 6*d.*, or at the rate of only 1·76*d.* per mile; for second-class passengers, 4*s.*, or 1·56*d.* per mile; and for third-class passengers, 2*s.* 6*d.*, or ·978*d.* per mile.

This line was opened to the public on the 1st July, 1840, from which time to the 19th of the same month inclusive, the number of passengers amounted to 12,809, the receipts for the same period on this account being 152*l.* 14*s.* 8*d.*, and for parcels 64*l.* 9*s.* 3½*d.*, or at the rate of about 674 passengers, and 83*l.* 14*s.* 11½*d.* per diem respectively, which gives a sum in proportion to about 30,570*l.* per annum.

The following is an account of the expenses from the commencement of the undertaking to 29th February, 1840:—

Expenses incurred to 31st August, 1836, including cost of survey			
in 1834			£ 7,908 19 2
Land, houses, and compensations			105,788 11 6
Contracts for works and stations	£ 141,827	14 6	
Rails, chairs, clips, freight, &c.	41,742	6 9	
Timber, posts, rails, and fencing	4,876	10 8	
Longitudinal and transverse sleepers, &c.	35,309	1 7	
			<hr/> 223,755 13 6
Engines, tenders, wagons, &c. on account			4,730 16 3
Parliamentary and law expenses, counsels' fees, conveyances of			
land, witnesses on jury-trials, &c.			10,274 3 3
Engineering and surveying			8,826 12 2
Direction			1,206 0 0
Secretary's and clerks' salaries, office-expenses, travelling ex-			
penses, advertising, printing, &c.; valuer's charges and ex-			3,244 3 0
penses, postages, &c.			
Interest on calls in advance, and on loans			3,854 9 3
			<hr/> £ 369,589 8 1

The original estimate for this railway in 1834, which included land and compensations for four lines of way, and 10% per cent for contingencies, amounted to 310,000*l.*; but the engineers recommended that a capital of 340,000*l.* should be raised, which would include the parliamentary expenses, and also the necessary stock of engines, carriages, and wagons. The parliamentary estimate, however, amounted to 400,000*l.*; and the Company obtained power by their Act to raise 133,000*l.* by way of loan.

The Directors reported to the shareholders at the last annual meeting, that the whole of the 133,000*l.* had been borrowed at 5% per cent interest.

In the engineers' report of January 1839, this excess is accounted for by the necessity of making additional compensations to Mr. Raikes and others to save the bill in Parliament; the purchase of additional ground at the Hull end; the construction of warping drains, and other works for the accommodation of individuals; the introduction of heavier rails; and the increased number of engines and carriages. These items together amount to upwards of 100,000*l.*

The works are altogether executed in a very substantial manner, according to the usual plan of Messrs. Walker and Burges; and the immediate superintendence has been entrusted to Mr. Lynde, Mr. Bray, Mr. John Timperley, and Mr. Fletcher, who appear to have given considerable satisfaction to the directors and engineers-in-chief.

LANCASTER AND PRESTON RAILWAY.

Of the forty-eight railways under the consideration of Parliament in the session of 1837, not one appears to us more likely to answer the expectations of its promoters than that between Preston and Lancaster, forming, as it does, a direct and easy link in one of the great chains of railway-communication between the metropolis and Scotland.

Mr. Locke estimated the entire cost of making the line at 250,000*l.*; and the maintenance of way, locomotive power, and other charges in carrying on the traffic, at 20,000*l.* per annum.

The course of this railway between the termini is very direct, and is traced from the station at Lancaster by Scotforth and Galgate, rather to the east of Garstang, west of Claughton Hall; crossing the Preston turnpike-road near Barton Lodge, and thence continuing to its junction with the North Union Railway in Dock Street, Preston.

Lengths of Planes.				Ratio of Inclination.		Locations.	
Miles.	Chains.						
0	20·27	. . . . .	level.				
0	64·45	. . . . .	ascending at the rate of 1 in	550			
0	92·31	. . . . .	level.				
1	51·04	. . . . .	descending	„	1 in	660	
3	40·72	. . . . .	level.				
1	63·72	. . . . .	descending	„	1 in	1060	

Lengths of Planes.		Ratio of Inclination.			Locations.
Miles.	Chains.				
0	60·81	. . . . .	ascending	„ 1 in 1320	
1	51·50	. . . . .	descending	„ 1 in 825	
1	37·18	. . . . .	descending	„ 1 in 1060	
0	37·31	. . . . .	level.		
2	10·00	. . . . .	ascending	„ 1 in 640	
2	21·31	. . . . .	ascending	„ 1 in 1060	
3	6·86	. . . . .	descending	„ 1 in 500	Junction with North Union Railway, Dock Street, Preston.
20	17·48				

The only unfavourable curve is that at the junction with the North Union Railway at Preston, which is of about 20 chains radius, but it is of less consequence, as being near a stopping-place.

EARTHWORKS. — The earthworks are rather heavy, the cuttings amounting to upwards of two millions of cubic yards, a considerable portion of which is deposited in spoil-banks. The slopes are generally $1\frac{1}{2}$ to 1. The average cost of the earthworks per cubic yard is about 10½d. The cuttings are 30 feet wide at bottom, including side-drains; and the embankments 33 feet wide under the line of ballasting.

The works, including the bridges and culverts, were let in three contracts, viz. the first, or Lancaster contract, extending over a distance of 6 miles 32 chains, to Mr. Perry, of Durham; the second, or Wyre and Barton contract, being a length of 12 miles 47 chains, to Messrs. Mullins and M'Mahon, of Dublin; and the third, or Preston contract, to Mr. J. Wilkie, of Preston, being for a length of 1 mile 3 chains.

The Lancaster contract had been considerably behindhand, owing to the inability of the contractor to provide a sufficiency of materials and the requisite number of men; the Company were in consequence obliged to provide the materials and labour necessary to complete the work.

This is another illustration of the absolute necessity of employing contractors of first-rate character and ample means. When we see these great works impeded for want of proper precaution on the part of those whose duty it is to look well into the real ability of contractors whom they are about to employ, we cannot but think that, in their over-desire to

economise the funds entrusted to them, they are apt oftentimes to take the lowest bidder; and although it may sometimes turn out advantageous, yet, for the most part, this apparent economy only entails on the Company a great additional outlay, and retards the progress of the works sometimes for many months. In the present instance, however, we are far from thus judging of the Directors of the Lancaster and Preston Railway; but we are anxious to warn those who may be unacquainted with this part of their duty, as directors of railways, to look well to the character and *real* ability of the contractors they are about to employ.

BRIDGES AND VIADUCTS. — The number of bridges, including viaducts, is altogether 48. The bridges over the railway are 30 feet wide, and 15 feet 6 inches high from rails to soffit. The width of bridges carrying the railway over roads, &c., is 25 feet between the parapets; the occupation-bridges under railway are each of 15 feet span; and turnpike-road bridges under railway, 16 feet high.

The viaduct at Galgate consists of six semicircular arches, each of 30 feet span, constructed of brick arches 1 foot 9 inches thick; and the whole faced with sandstone. The piers are 25 feet high from the bottom footing to the springing of arches, and are each 5 feet, and the abutments 6 feet in thickness; the latter are strengthened with contreforts 6 feet in thickness. The whole width of viaduct, including parapets, is 27 feet 4 inches; the height from Galgate to the surface of rails is about 39 feet; and the total length of viaduct 265 feet. The parapets are each 14 inches in thickness, and 4 feet in height.

Spanning the Wyre river there is also a viaduct of six arches, which are each of 30 feet span, but of semi-elliptical form, having a versed sine of 9 feet. The arches are 18 inches in thickness; and the piers, which are founded on concrete, are 4 feet thick. The width of viaduct is 25 feet between the parapets; and the whole length 262 feet.

GAUGE OF WAY, &c.—The whole width of land taken for the railway is about 50 feet. The gauge of way is the same as the English standard, viz. 4 feet 8½ inches; the intermediate space 6 feet 5½ inches. On bridges the side-space is 4 feet 6 inches; and on embankments 7 feet wide respectively.

The rails are of the parallel form, weighing 65 lbs. per lineal yard (see Plate III. fig. 29): they were chiefly supplied by Harfords and Co., of Bristol, and Bailey Brothers, of Liverpool, the average cost per ton being about 11*l.*; the whole weight of rails exceeds 4,000 tons. The rails are secured to chairs by wooden keys, in the manner now generally adopted for this form of rail.

The chairs, which were supplied from the same respectable firms, cost about 7*l.* 2*s.* per ton, and weigh altogether upwards of 900 tons. The intermediate chairs are 10 inches long, 5 inches wide, and 5 inches high, and weigh each about 19½ lbs. The joint-chairs are of the same form, but of rather heavier weight.

The sleepers used on the embankments, which are of larch 9 feet long, and scant 10 inches by 5 inches, were supplied from the neighbourhood of Carlisle: upwards of ten thousand have been used.

The stone blocks contain each about 4 cubic feet; not fewer than 85,400 have been used for the cuttings. Felt is used to bed the chairs on the blocks. The prices of the sleepers varied from 2*s.* 5*d.* to 2*s.* 10*d.* and 3*s.*; and of the blocks from 2*s.* 7*d.* to 4*s.* 6*d.* and 5*s.* each.

The ballasting consists either of broken stone or of gravel and sand, 12 inches in thickness; and on the highest embankments 14 inches in thickness.

DRAINAGE AND FENCES.—The open drains at the foot of the embankment-slopes are 3 feet wide and 1½ feet deep; and the field-drains outside the fencing are of the same dimensions. The culverts in general use on this line are of 18 inches, 24 inches, and 36 inches diameter respectively; the smallest size being half a brick thick, and the two other sizes each of one brick in thickness.

The fencing consists of stout posts and three rails; the posts are 4 feet high, and 5 feet apart. A quick hedge is planted at the bottom of the embankment-slopes on a bench 1½ feet wide, formed for that purpose. The fencing is placed outside, and at a distance of 2 feet from the open drain. On the level of lands above the slopes of cuttings there is a width of 6 feet to the wooden fence, in the middle of which space the quick is planted, the field-drain being outside the fence.

The occupation field-gates have five bars, and are each 4 feet high and 8 feet 9 inches wide, having a vertical brace in the middle. The hanging and shutting posts are each 6 inches \times 6 inches, and let into the ground for at least $2\frac{1}{2}$ feet.

STATIONS.—The Lancaster station is situate at the entrance to the town, and at the divergence of the Preston and Cockerham roads. The land enclosed for this station contains nearly six acres. The offices, which front the town, are of neat elevation, the whole being constructed of sandstone from the immediate neighbourhood. When at this station in April last, it was in so unfinished a state that we could not clearly make out the intended arrangements.

CARRIAGES AND LOCOMOTIVE ENGINES.—The carriages used on this line are first, second, and third-class, of the ordinary construction.

The directors have contracted with the North Union Company for the supply of locomotive power for one year, an arrangement which will, no doubt, be attended with considerable advantage.

TRAINS AND FARES, &c.—The number of trains at present traversing this line daily is five in each direction. The fares for first-class passengers are 4s., for second-class 2s. 6d., and for third-class 1s. 6d.; being respectively at the rates of 2·36d., 1·48d., and ·89d. per mile.

The line was opened to the public on the 26th June, 1840, rather more than three years from the date of the Act of incorporation.

It is much to be regretted that the cost of this line has so far exceeded the estimate which was laid before Parliament, and which was at the rate of only 12,500*l.* per mile; whereas it was stated by the chairman at the last annual meeting, in June 1840, that the cost would amount to as much as 20,000*l.* per mile! Had the gradients corresponded more with those of the Grand Junction line, the actual cost would not, in all probability, have exceeded the original estimate by more than 25 per cent.

LEEDS AND SELBY RAILWAY.

LEEDS has long been noted as the principal woollen mart of Great Britain. To this trade it owes its importance; and to this trade may chiefly be attributed the existence of the Leeds and Selby Railway, nearly the whole capital being raised within this district, and the leading proprietors being some of the principal woollen manufacturers in the kingdom.

Antecedent to the formation of this line, the wool imported from foreign countries into Hull and intended for Leeds was conveyed thither chiefly by the rivers and canals. By the introduction of this railway, the actual distance between Leeds and Selby, as compared with the existing navigation, was at once reduced from twenty-eight to twenty miles, besides the avoidance of nine locks. So great were considered the advantages likely to accrue to the public by the formation of a railway between Leeds and Selby, that the capital was readily subscribed for; but although every work of this kind must be considered nationally advantageous, yet the Leeds and Selby, until the opening of the York and North Midland line, had proved but a bad speculation to the proprietary. This comparative failure we attribute not to the railway itself, but to want of proper management. A railway, or other great work, commenced and carried on during its execution in a spirited manner, should also be afterwards efficiently worked, or the results will inevitably prove as they have done in the case of the Leeds and Selby Railway. A manifest improvement is, however, now taking place in this concern, which bids fair to rank shortly among some of the more prosperous and better-managed railways of later times. To Mr. Clarke, the present superintendent, much credit is due for the activity and zeal he has displayed in the cause of the shareholders ever since his appointment.

ACTS OF PARLIAMENT.—The Act for the incorporation of this Company received the royal assent on the 29th May, 1830. The Company were by it empowered to raise a capital of 210,000*l.* in 2100 shares of 100*l.* each; and by loan an additional sum of 90,000*l.* A second Act was obtained in the session of 1835, which received the royal assent on the 3d July, and authorised the Company to raise an additional loan of 40,000*l.*, making altogether 340,000*l.*

The railway was publicly opened on the 22d September, 1834, a period of upwards of four years from the date of the first Act of Parliament. The half-yearly report of December 1839 is an earnest of the intended exertions of the directors of this railway for the public good; being determined to avail themselves of every practical improvement, whether of machinery or management, to bring the working of the concern into as efficient a state as that of any other railway in the kingdom.*

COURSE OF THE LINE.—This railway, which in part forms a link of the great transverse line from Liverpool to Hull, runs in a direction nearly east and west. From the Leeds station and depôt, which are situate in Marsh Lane, the course of this line is traced through the parishes of Leeds, Whit-church, Barwick-in-Elmet, Garforth, Aberford, Sherburn, Brayton, and Selby, the eastern terminus being close to the river Ouse, and about 260 yards below the bridge at Selby.

INCLINATIONS.—As the line was originally laid out, the following, commencing at Leeds, were the inclinations, viz. 1 in 210, 1 in 176, and 1 in 152, ascending; then the summit-level plane, from which the following inclines descended towards Selby, viz. 1 in 152 and 1 in 135, the Selby terminal plane being level.

According, however, to the Tables of Gradients published by Mr. Bradshaw, of Manchester, and which we have reason to believe are generally correct, the inclinations of this way appear to be quite altered, of which we were not at all aware until consulting this authority.

Commencing at Leeds, the inclinations are as follows :—

Lengths of Planes.		Ratio of Inclination.		Locations.
Miles.	Chains.			
	8·00	level.		
	8·00	ascending at the rate of 1 in	218	Entrance to tunnel.
	31·80	ascending „ 1 in	349	End of tunnel.
	18·00	ascending „ 1 in	229	
	57·20	ascending „ 1 in	210	
2	4·80	ascending „ 1 in	160	

* The York and North Midland Company, since the above was written, have offered to take a lease of this railway for thirty years, and to have the option of purchasing it at the end of that period

Lengths of Planes.		Ratio of Inclination.			Locations.
Miles.	Chains.				
1	4·20	. . . . .	ascending	„	1 in 168
2	61·00	. . . . .	level.		
2	47·00	. . . . .	descending	„	1 in 150 { End of New Street cutting.
3	21·00	. . . . .	descending	„	1 in 137 { Occupation-road to Milford.
	18·00	. . . . .	descending	„	1 in 182
6	41·00	. . . . .	descending	„	1 in 3785 Selby station.
20	00·00				

This railway, therefore, in point of gradients, will come under the second class. By reference to the above table it will be seen that the line ascends to the summit-level for a length of 4 miles 52 chains, the whole rise being 132 feet 4 inches. The descent from the summit-level to Selby is 232 feet 4 inches, and the distance 12 miles 47 chains. There is a difference of exactly 100 feet between the level of the way at Leeds and at Selby, the former being the highest.

CURVES.—The curvature is generally easy throughout; the quickest is a reversed curve in the parish of Leeds on the east of the tunnel, the radii of which are each of about 40 chains.

EARTHWORKS.—Some of the embankments are of considerable height; and instead of being carried up with regular slopes, have their sides faced to a curved batter, the chord-line of which forms an angle with the base of about $67\frac{1}{2}^{\circ}$. Where stone is plentiful, this is decidedly an economical mode of constructing embankments; for not only is the quantity of earthwork very much reduced, but there is also a considerable saving effected in the area of land required. The same observation will apply to the lower portions both of cuttings and embankments; for by carrying up retaining walls for about $1\frac{1}{2}$ to 2 yards in height, the quantity of excavation is much reduced, and also the area of land. On some of the principal railways this plan might have been carried out to great extent, and with considerable advantage. Where stone-fence walls are placed on the top of the embankments, the whole width is 30 feet, and the clear width 27 feet.

The principal embankment is that between the Ferrybridge and York Road and Bonnyfield Lane, which is $1\frac{1}{2}$ miles in length. The greatest height of any embankment is upwards of 50 feet. The total length of cuttings is about $6\frac{1}{2}$ miles; the longest cutting, which is in the parishes of Whitchurch and Barwick-in-Elmet, extends over $1\frac{1}{2}$ miles. The greatest depth of cutting is about 43 feet.

The strata cut through consist chiefly of sandstone, limestone, clay, and marl.

TUNNEL AND BRIDGES.—The Leeds tunnel, which is 8 chains from the terminus, and which has two lines of way throughout, is 700 yards in length, 22 feet wide at springing of semicircular arch, 17 feet high from the level of rails to soffit, and 19 feet from invert to soffit. It is walled and arched throughout with 18-inch brickwork. The strata through which the tunnel is driven consist of about two-thirds of shale and coal-measures, and the remainder of rock. The surface of ground above the railway is about 80 feet. Three shafts were sunk for the execution of the work, 10 feet in diameter, which are left open for the purposes of light and ventilation. These are considerably contracted in size where they meet the arch of the tunnel, each being about 8 feet in its conjugate, and 5 feet in its transverse diameter. For ventilation they are found to answer fully; but the speed at which the locomotive passes through the tunnel, added to the cloud of steam and dust issuing from the chimney, renders the shafts of no use as regards lighting the carriages. The cost of this tunnel is stated to have averaged about 25*l.* a yard lineal.

The bridges throughout this work are not inferior to those on any railway in the kingdom; indeed some of them are of very bold design and of excellent proportions, and the masonry is altogether well executed. All the bridges over the railway are of sufficient width for four lines of way; this, as it has turned out, might have been advantageously avoided. If, however, the traffic should increase to a considerable extent, another line of way may be laid down at comparatively small cost; or if, hereafter, special trains should be introduced to run at high velocities, either for the purposes of the state or of commerce, or for a mass of the locomotive public who would readily pay much higher fares to attain this desirable end—then would the

Leeds and Selby Railway Company have the advantage over other companies, in being possessed of land and bridges of sufficient extent and size for the increased accommodation required.

There are forty-three bridges to carry the railway over and under roads, including six over turnpike-roads, and two over coal-ways; besides about twenty culverts, some of which are of large dimensions.

The turnpike-roads from Leeds to Selby, and from Ferrybridge to York, are passed under the railway.

LEVEL CROSSINGS.—The turnpike-road from Wakefield to Aberford is crossed on a level, and is furnished with a convenient lodge and gates. We counted, on our view of this way, not fewer than sixteen other level road-crossings and thirty-four occupation field-crossings.

LAND.—The land taken throughout is of sufficient width for four sets of rails, though the way is only formed for two.

GAUGE OF WAY, &c.—The gauge of way is 4 feet 8½ inches; the intermediate space at the Leeds station 5 feet; and at other places rather more. The side-spaces vary considerably in different parts.

The rails used on this line are of the same weight as those first used on the Liverpool and Manchester Railway, viz. 35 lbs. to the yard. They are of the T or single parallel form, and in 15-foot lengths, fixed in small chairs at intervals of 3 feet, set either on stone blocks or larch sleepers. Some of the blocks have been relaid diagonally, as last introduced on the London and Birmingham Railway. The blocks from Halton quarry, being found very unfit for the purpose, have been replaced with those of Bramley fall stone. In some portions the stone blocks are continuous under each rail, and are connected together with iron ties running across the way, to keep the rails in proper gauge; chairs are, however, used here in the ordinary way; the blocks so used are 3 feet in length, 16 inches wide, and 12 inches thick. New rails, of 42 lbs. to the yard, have lately been introduced on this line.

The ballasting is formed chiefly of broken stone. The mile-standards are placed on each side of the railway, at intervals of a quarter of a mile; a plan which would be attended with advantage on all railways.

The drainage appears to have received due attention throughout. The open drains running parallel with embankments are 4 feet wide at top, 1 foot 6 inches at bottom, and 3 feet deep.

The fencing consists of stone walls, some of which are 5 feet 6 inches high, 9 inches wide at top, and 2 feet 7 inches at bottom; and wooden fencing with three rails. The quick hedges are now in a thriving condition; but the fences in some parts have lately required considerable outlay in repairs. At the bottom of some of the cuttings on this railway, by the side of the open drain, a post-and-rail fence is fixed up: this is hardly required, if there be a good fence at the top of the slope next the lands.

STATIONS AND DEPÔTS.—Besides the stations at Leeds and Selby, there are five intermediate stations, viz. Garforth, Micklefield, Milford, York Junction, and Hambleton.

The Leeds station is in Marsh Lane: an appropriate building standing in a court-yard, and of neat elevation, contains the booking-office on the ground-floor; and above, the superintendent's and clerks' offices, which are on the same level as the railway. A spacious staircase ascends from the passage in front of the booking-office to the railway, which is here laid with four sets of rails, and carried under a commodious shed in three spaces, supported on cast-iron columns. The middle space has two lines of way; the intermediate space is 5 feet, and each of the side-spaces 3 feet 5 inches. A single way is laid under each of the side-spans. There is, however, no platform on either side, so that the passengers are obliged to mount into the carriages by the carriage-steps, which is attended with considerable inconvenience, especially to ladies. The arrangement of the Leeds station is not in keeping with the general design of this railway. The triple way continues to the mouth of the tunnel.

The depôt is contiguous to the station. Here there are commodious warehouses; and a new one has lately been erected for the purpose of keeping the passenger-shed free from the mixed business which has hitherto been carried on in it, to the great annoyance of the passengers. The superintendent's house faces Marsh Lane. A locomotives' repairing-shop and smithy with eight hearths, and furnished with benches for about ten workmen, are conveniently placed on the north side of the depôt. In the engine-shop there

are two races, and a 13-foot engine turn-table. The water-tank is calculated to hold 2000 gallons, or sufficient to fill the cisterns of three tenders. At this depôt there are two common road-docks, on the wharfs of which are laid four lines of way running parallel to each other, under each of which is a series of cart-recesses, eight in number; the spaces between the brick partitions of which being open at top, the coals and lime from the railway-wagons above are readily shot into the road-carts below.

At Selby the station has the same fault exhibited in its arrangement as that of Leeds, viz. the want of platforms. It is otherwise a spacious and well-proportioned building, divided down its length into three spaces by two lines of cast-iron columns, which support the three spans of roofing. There are altogether seven lines of way running quite through this building, with as many carriage turn-tables, each placed half-way along the shed. The middle space, which has a triple way, is about 35 feet wide; and the side-spaces, each having a double way, 24 feet 6 inches each. The gates to the middle space are made to slide; and those to each of the side-spaces are hung folding. As one line is calculated to hold fourteen carriages, there is altogether space sufficient for ninety-eight carriages and wagons within this shed. There is an engine turn-table conveniently placed at the south entrance.

The railway passes through the shed, and on to a steam-boat jetty projecting into the river Ouse. The offices are placed on the left of the shed, and at the end next the river.

The intermediate stations are furnished each with a neat cottage-building, wherein, besides the passengers' waiting-room, there is a kitchen and living-room, and over the latter a bed-room for the use of the station-clerk. At the Milford intermediate station, the platform in front of the building is 8 feet wide and 6 inches high, which is certainly not sufficient by about a foot, for the reason we have stated above in describing the Leeds and Selby stations. The side-space at this station is 2 feet 2½ inches, and the intermediate space 4 feet 8 inches.

The Micklefield station is close to the turnpike-road to Wetherby.

CARRIAGES AND WAGONS, &c.—The carriages consist of first and second-class, and are nineteen in number, viz. six first-class and thirteen second-class. Both descriptions agree nearly with the plan of carriages ordinarily

used on other lines. The first-class carriages are furnished at night with outside oil-lamps. We observed one first-class carriage with a coupé in front and also behind.

							tons.	cwt.	qrs.
A first-class carriage weighs	.	.	.	.	.	.	3	2	2
A second-class ditto	.	.	.	.	.	.	2	10	2
An average truck	.	.	.	.	.	.	1	11	0
Mr. Gascoigne's wagons	.	.	.	.	.	.	1	16	0
Mr. Lumb's lime-wagons	.	.	.	.	.	.	1	14	0
Mr. Ward's wagons	.	.	.	.	.	.	1	15	0

The horse-boxes on this line are very different to those now generally adopted, being much the same as those used to convey horses on board steam-boats; each holding only one horse. The length of a horse-box is 8 feet, width 3 feet 1½ inches, and height 4 feet 9 inches. It is constructed chiefly of wood; four uprights on each side, 2½ inches square, and reaching to 5 inches above the sides; sills 5 × 3 inches; bottom plank, or floor, 1½ inches thick; and sides of ¾-inch plank. The door is at one end, hung with stout hinges and fastenings, and having a strong fastening-bar across outside, with staple complete. There are four semicircular irons running from side to side, to which may be secured a covering in case of stormy weather. Two horse-boxes may be placed in an ordinary-sized truck.

The trucks are 10 feet long, 7 feet 6 inches wide; the floor is of 11-inch planks, 1½ inches thick; four joists, 6 × 2½ inches, and projecting over the soles on each side 6½ inches; the height between rails and under side of soles is 2 feet 6 inches; four 3-foot wheels, 5 feet 2 inches from centre to centre of each axle; inside bearings, and 3-foot steel springs.

The turning platforms for carriages are of iron, and 7 feet in diameter. Cast-iron wheels, with wrought-tires, are used for the trucks, having each ten hollow spokes, similar to some of the wheels used on the Liverpool and Manchester way. They are from the works of Warrington and Crossland, of Bradford.

TRAINS AND FARES, &c.—There are four trains daily between Leeds and Selby in each direction, all of which call at the York Railway junction; besides which there is a mid-day mail-train between Leeds and York in each

direction. The carriages of each Company run on either railway, as may be required. On Sundays there are two trains daily between Leeds and Selby in each direction, one in the morning, and one in the evening; and from York there is also the mid-day mail-train.

In the two years 1838 and 1839, the number of passengers conveyed on this line amounted to 261,639, or, on an average, 358·40 per diem. In 1839, the second to first-class passengers were as 3 to 1.

A merchandise-train leaves Leeds at midnight, and returns from Selby at 6 A.M. There is also another merchandise-train in the course of the evening.

The first-class fare for the whole distance is 4*s.*; and the second-class fare 3*s.* The average fare, therefore, per mile for first-class passengers is about 2½*d.*; and for second-class passengers 1½*d.* Originally the fares were 3*s.* and 2*s.* respectively; and for a short time in 1837 they were 5*s.* and 4*s.*

The time allowed between Leeds and Selby for the passenger-trains is one hour, including stoppages; and for the merchandise-trains two hours. The tickets are taken previously to the starting of each train.

The signals used are flags by day; and coloured lamps, with reflectors furnished by Lowe, of Birmingham, by night. Tickets of different colours are used for the different stations.

We found the average weight of thirteen trains on this line to amount to 61,082 lbs.; the average velocity to 21·19 miles per hour; the highest velocity to 44·11 miles per hour; and the stoppages to occupy, on an average, each 1·047 minutes. (See Table G. of Results of Practical Experiments, in the Appendix.)

LOCOMOTIVES' DEPARTMENT.—The engines in use on this line are necessarily four-wheeled, on account of the light rails. In 1839, the engines at work were chiefly constructed by Messrs. Fenton, Murray, and Co., of Leeds; several new engines have lately been introduced from these works, and also from Messrs. Kirtley and Co.'s, of Warrington. Until the present year, the engines had been used promiscuously for the passenger and goods-traffic. Nine new engines have been lately introduced on the line purposely for the passenger-trains; the old engines having been repaired and refitted entirely for the goods-traffic.

The Swallow, Gambier, and Swift, each cost 1200*l.*, exclusive of tenders;

the Dart and Express each 1350*l.*, tenders included; and the Eagle 1400*l.*, also including the tender.

There are five tenders, built by Edward Bury, of Liverpool, which cost each from 250*l.* to 270*l.*; and we were informed that five new ones were building. Each tender holds about 50 cubic feet of coke, and 700 gallons of water.

An assistant engine is used at the Milford Inclines of 1 in 137 and 1 in 150, when the trains are heavy.

The following salutary notice is posted up at the Leeds depôt:—"Both the engineman and fireman of any engine from which coke is thrown during the time they are on the road, will be fined. All refuse coke to be thrown out of the tender in the depôts." The fine, however, in such case should be rigidly exacted. We have seen much coke thrown away on some lines, which the firemen did not approve of. It would be invidious to mention the railways where this direct fraud is committed; but it behoves all railway-companies to direct the superintendents of locomotives, and also the police, to keep a vigilant eye on those by whom it must be committed.

There are, on an average, six engines at work on this line daily. The engine which takes the first morning-train to Selby returns with the second morning-train from Selby; and the same engine leads the three o'clock P.M. train from Leeds to Selby, and returns from Selby at six P.M. The engine which leads the first morning-train from Selby to Leeds returns with the second morning-train from Leeds; and in the afternoon leaves Selby with the first train, and returns from Leeds with the second afternoon, or six o'clock train.

The coke used on this line is from near Barnsley; from Earl Fitzwilliam's collieries, near Rotherham; and from Shelf, near Bradford.

The water-stations are at Leeds, at Selby, and at Garforth: at the latter places the water is of excellent quality; but at Leeds, being impregnated with lime, it tends to the speedy destruction of the boilers.

ANNUAL EXPENSES.—Mr. Clarke, the general superintendent, informed us that there were about seventy-five waymen regularly employed. The policemen on the line, who attend to the points and level crossings, are twenty in number, each of whom receives 17*s.* 6*d.* a week. Besides the

superintendents of engines, of the coaching department, and of the way, respectively, there are seven smiths, at from 24*s.* to 28*s.* per week; six fitters, at from 28*s.* to 30*s.* a week; and nineteen cleaners and coke-fillers at from 15*s.* to 18*s.* a week each. The engine-drivers earn 30*s.*, and the firemen each 15*s.* a week, respectively. At Selby there are sixteen porters on jetties, each at 18*s.* a week; two shipping-clerks, each at 21*s.*; two coal-tippers, each at 18*s.*; a depôt-clerk, 30*s.*; night-watchman, 20*s.*; foreman on jetties, 40*s.*; three carriage-porters, each 18*s.*; two coke and water-fillers, each at 20*s.*, and one at 15*s.* There are also one engine-man, one smith, and one striker.

The following exhibits the annual cost of the maintenance and working of this railway, from the 1st January, 1837, to 30th June, 1840:—

Repairs of and working the locomotive engines	£17,822	4	1
Maintenance of way	16,675	10	2
Cost of coke	9,202	4	3
Office and police establishment	5,436	19	10
Coach, coal and lime, wagon, and merchandise disburse- ments	18,545	8	8
Compensation	811	2	1
Rates and assessments	2,386	10	9
Government-duty on passengers	3,510	10	2
General account, including interest, and commission to bankers	3,755	6	1
Law expenses	961	8	1
Interest on loans	17,987	12	10
New engine account	7,657	0	0
Construction of the way	1,855	5	10
New rails	273	2	3
Depôts and station-houses	4,565	16	3
Stationery account	293	19	9
In reduction of the old construction account	2,000	0	0
	<u>£113,740</u>	<u>1</u>	<u>1</u>

The annual cost for this period was on an average at the rate of 32,497*l.* 2*s.* 10·56*d.* per annum, the gross receipts for the same time being 127,264*l.* 12*s.* 6*d.*, which is at the rate of 36,361*l.* 5*s.* 5·14*d.* per annum. Thus the expenditure amounted on an average to 89·32 per cent on the gross revenue: the profits arising from the undertaking during the three

years and a half as above amounted to 13,524*l.* 11*s.* 5*d.*, which is at the rate on an average of 3,864*l.* 3*s.* 3·14*d.* per annum, or only 1*l.* 16*s.* 9*d.* per share; but for the last half year, ending 30th June, 1840, the profits amounted to 2*l.* per share, or 4*l.* per cent per annum on the 100*l.* shares.

This line was surveyed by Mr. Comrie, under the direction of Messrs. Walker and Burges, who laid out the line, and under whose general direction the works were carried into execution; Mr. George Smith, now of Belfast, being the resident engineer during the progress of the works.

LEICESTER AND SWANNINGTON RAILWAY.

MR. GEORGE STEPHENSON, the celebrated railway-engineer, is one of the directors of the Leicester and Swannington Railway, and is largely interested both in the Leicestershire and Derbyshire coal-fields. To this gentleman is the public indebted not only for the introduction of the improved locomotive engine, but also for the reduction in the price of inland coals.

The Leicester and Swannington Railway connects the coal-field near Ashby with the town of Leicester. Its principal use is the carriage of coal, Groby granite, and paving-stones, from the collieries and from the quarries, which are not only consumed and used in Leicestershire, but are also introduced into the London market.

ACTS OF PARLIAMENT, CAPITAL, &c.—This Company have obtained three Acts of Parliament, authorising them to raise altogether, in joint stock and by loan, 175,000*l.* The Act of incorporation received the royal assent on the 29th May, 1830, by which the Company was empowered to raise a joint-stock capital of 90,000*l.*, and an additional sum by loan of 20,000*l.* The second Act is dated 10th June, 1833, and contains clauses giving the Company power to augment their capital by the sum of 10,000*l.*, and to raise an additional loan of 15,000*l.* The last Act received the royal assent on the

30th June, 1837, and authorised the Company to raise a further sum in joint stock of 40,000*l.* The capital of the Company is 140,000*l.* divided into 2,800 shares of 50*l.* each.

GENERAL DIRECTION OF LINE AND INCLINATIONS.—From Leicester the line runs for about six miles in a westerly direction to the north of Desford; thence, taking a course nearly north-west, continues to its termination near Breedon.

The whole length of this line is 28,270 yards, or 16·0625 miles. From the depôt at Leicester near the West Bridge, it ascends to the summit for 11·375 miles as far as Barlston Lane. In this length there are two level planes amounting to 1·737 miles; and eight planes, inclining at the rates respectively of 1 in 147, 1 in 754, 1 in 480, 1 in 364, 1 in 211, 1 in 138, 1 in 119, and 1 in 29. From the summit, which is 371 feet above the Leicester terminus, it makes a descent for 4·562 miles in four planes, having inclinations of 1 in 97, 1 in 203, 1 in 251, and 1 in 17.

The western terminal plane is level for a length of 242 yards. This line, therefore, having inclinations of 1 in 17 and 1 in 29, comes under the fourth class of railways in this respect.

The Bagworth Incline of 1 in 29, and the Swannington declivity of 1 in 17, are worked by fixed-engine power.

The line is single throughout, except at the stations. The gauge of way is 4 feet 8½ inches; the rails are of fish-bellied form, fixed in chairs, with three-feet bearings. Both stone blocks and wooden sleepers are used. At the Leicester station there are four lines of way with numerous cross-lines furnished with turn-tables.

The principal work on the line is the tunnel, about 1½ miles from the Leicester depôt. It is about a mile in length, 13½ feet in clear height, and 10 feet 8 inches wide at level of rails; the arch is semicircular, and described with a radius of 5 feet 8½ inches. The whole is constructed of brickwork 18 inches in thickness.

This work was executed by means of four vertical shafts, each of about 5 feet diameter; and eight smaller shafts, each of 3 feet diameter.

CARRIAGES AND ENGINES.—The carriages used on this line are for first and second-class passengers.

The usual coal-trains consist of twenty-four wagons, each weighing 32 cwt.; so that the net weight of a train is 38 tons 18 cwt.

The proportions of the locomotive engines used in this line will be found in Table IX. of British Locomotive Engines in the Appendix.

FARES, TRAFFIC, &c. — The line was opened on the 17th July, 1832, at which time the fares charged were 2·461*d.* per mile and 1·23*d.*, for first and second-class passengers respectively; afterwards they were lowered to 1·458*d.* and 0·96*d.*; and at the present time they are 1·894*d.* for first-class, and 1·342*d.* for second-class passengers. The number of persons conveyed on this line in the years 1838 and 1839 amounted to 45,044, or on an average at the rate of 61·704 per diem. The charge for coals, lime, and sand, is at the rate of 2*d.*; for broken granite for roads, 1½*d.*; and for building-purposes and paving, 2½*d.* per ton per mile.

The receipts for the years 1837, 1838, and 1839, amounted on an average to 19,924*l.* 11*s.* 2·33*d.* per annum; and the disbursements to 11,276*l.* 8*s.* 3·66*d.*, or 56·59*l.* per cent on the gross revenue. The average profit per annum for the same period amounted to 8,648*l.* 2*s.* 10·67*d.*, being equal to 6·17*l.* per cent on the Company's capital of 140,000*l.*

The maintenance of way for the three years cost at the rate of 130*l.* 14*s.* per mile; and the locomotive power and repairs of engines amounted on an average per annum to 2,099*l.* 13*s.* 2*d.*, or more than one-fifth of the whole annual expenditure.

The original estimate was 90,000*l.*, or at the rate of about 5,603*l.* per mile: the actual cost has been about 7,970*l.* per mile.

LIVERPOOL AND MANCHESTER RAILWAY.

THE Liverpool and Manchester may truly be designated the Grand British Experimental Railway. The general extension of the railway-system, not only throughout our own country, but also over the continents of Europe

and America, is mainly owing to the success of this important work. They truly should be numbered among England's benefactors whose names are recorded in the prospectus first issued by this Company. So great was their zeal in this formidable undertaking, that notwithstanding the violent and costly opposition which they met with in their first application to Parliament, they proceeded with renewed vigour during the recess to prepare themselves with more perfect plans and sections for a second application in the following year, so fully were they convinced, that although they might incur a vast outlay before they could even obtain an Act of Parliament, their efforts would be crowned with success, and the results prove nationally advantageous.

Their second application was not in vain: the bill for executing this magnificent undertaking received the royal assent on the 5th of May, 1826; and on the 15th of September, 1830, it was opened to the public.

ACTS OF PARLIAMENT, &c. — The Act of incorporation received the royal assent on the 5th May, 1826, by which the Company were authorised to raise a joint-stock capital of 510,000*l.*, and by loan 127,500*l.* The second Act, which was passed in the session of 1827, and is dated 12th April of that year, empowered the Company to raise a further loan of 100,000*l.* On the 14th May, 1829, an addition to the capital of 127,500*l.* was allowed to be raised by the Company's third Act in 5,100 quarter shares. The fourth Act was obtained on 23d May, 1832, by which an additional sum of 200,000*l.* was authorised to be raised by loan; and by the fifth Act, dated 5th May, 1837, a further sum of 400,000*l.* also by loan.

For the extension of this line to that of the Manchester and Leeds Railway, an Act was obtained in 1839, which empowered the Company to raise a sum of 208,000*l.*; but the object contemplated by this measure is at present no further advanced than when the Act was passed. This is much to be regretted, as the intended junction-line is the only link wanting to complete the great transverse chain between Liverpool and Hull.

The original estimate for this railway was 300,000*l.*: the revised estimate amounted to 510,000*l.*; but up to 31st May, 1830, the amount expended on the works, &c., reached the sum of 739,185*l.* 4*s.* 10*d.*; and up to the present time, 1,224,000*l.* The whole amount authorised to be raised by the several Acts up to 5th May, 1837, is 1,465,000*l.* Of this amount the Com-

pany have raised altogether 769,875*l.* by shares, and 427,500*l.* by loan, making together 1,224,375*l.* By certain clauses in the Acts of Parliament, the Company are to reduce the tolls whenever the dividend exceeds 10*l.* per cent.

GENERAL ROUTE. — From the Liverpool terminus in Lime Street, the line passes under part of the town, by means of the tunnel, to Edgehill, where is situate the first intermediate station : at this point also is the divergence of the line to Wapping, and branch to Crown Street. From Edgehill it passes severally by Broad Green, Roby, Whiston, Rainhill, Sutton, and over Parr Moss to Newton. Near this station, which is about midway between Liverpool and Manchester, the Grand Junction Railway diverges to the south ; and a little beyond, at Parkside, is the junction of the North Union Railway, from whence the line passes to Kenyon. Here the Kenyon and Leigh Railway diverges to the left. From the Kenyon junction it continues to Chat Moss, which is intersected for a length of about four miles. Slightly curving by Eccles, the line continues to Salford, and crosses the river Irwell to the Manchester station and depôt in Water Street and Liverpool Road. The quickest curve is between the river Irwell and Ordsall Lane, being of about a quarter of a mile radius.

INCLINATIONS. — Commencing at Lime Street station, Liverpool, the first plane, which is worked by the stationary engines at Edgehill, ascends at the rate of 1 in 88 for a distance of 1 mile 30 chains ; the next plane is level for 28 chains ; then succeeds a descent of 1 in 1094 for 5 miles 23 chains, to the foot of the Whiston Incline, which ascends at the rate of 1 in 96 for 1 mile 47 chains. Next in order is the Rainhill summit-level, which is 1 mile 7 chains in length, and 133·76 feet above the Liverpool station. The Sutton Incline descends for 1 mile 39 chains, at the rate of 1 in 89. The railway still continues to descend for 9 miles and 21 chains in two planes ; the first being 2 miles 41 chains in length, and falling to the Sankey viaduct at the rate of 1 in 2762 ; and the latter, for a distance of 6½ miles to Bury Lane, at the rate of 1 in 894.

The remaining portion of the line is on an ascent to Manchester, and is in two planes ; the first rising at the rate of 1 in 1300 for 5 miles 62 chains,

and the Manchester terminal plane, which is 4 miles 36 chains in length, at the rate of 1 in 4257.

In the descending plane over Chat Moss, and near Lamb's Cottage, there is a very steep rise for a short distance, but which is never discovered by travellers; nor has it ever been included in the published tables of gradients of this railway.

The whole length of railway, therefore, from Lime Street, Liverpool, to Water Street, Manchester, is 30·66 miles. The ascending planes between Liverpool and Manchester amount to 13 miles 15 chains, the greatest inclination being 1 in 96; the descending planes to 14 miles 50 chains, the greatest inclination being 1 in 89; and the level planes to 1 mile 35 chains. This railway, therefore, according to our classification, is of the third class in point of gradients.

EARTHWORKS.—Few railways which have been executed since the Liverpool and Manchester line have had a larger amount of earthworks per mile; and certainly none have presented, upon the whole, greater difficulties in effecting their removal. The strata intersected consist of earths, peats, sands, shale, and rock. The total amount of earthworks is about 2,728,000 cubic yards, or upwards of 90,000 yards per mile, and cost about 1*s.* 5½*d.* per yard. Against this, however, must be set the value of stone removed from the Olive Mount cutting, which was used for the bridges, and other masonry in that district. The railway over embankments is generally protected with earthbanks, properly sodded. This plan was originally adopted to check the progress of an engine which might get off the rails, but is not followed in railways of more recent date; although we are of opinion that it would be an example worthy of imitation on the lofty embankments of the main lines in the kingdom, if only to afford to the traveller an appearance of safety, although the reason already given is of sufficient importance to cause their general adoption.

TUNNELS.—There are not fewer than three tunnels at Liverpool, viz. that descending to Wapping, at the rate of 1 in 48, its length being 2216 yards, width 22 feet, and height 16 feet; the Crown Street tunnel, the eastern face of which is in the same line as that of the Wapping tunnel, but which is on

an ascent to Crown Street, whereas the Wapping tunnel passes under it: it is 290 yards in length, 16 feet 9 inches wide, and 12 feet high; and the Lime Street tunnel, which is about 2000 yards in length. This latter work cost no less a sum than 160,000*l.*, and the annual cost of working the incline through the tunnel amounts to about 2000*l.* a year.

BRIDGES.—There are no fewer than thirty-six bridges over the railway, and twenty-nine under, including the viaducts; twenty-one level-road crossings, and twenty-nine field and occupation-crossings.

We found a bridge over the railway at Kenyon to measure 30 feet 10 inches in span, and its height from the rails to the soffit of arch 15 feet 6 inches, the rise of semi-elliptical arch being 8 feet; the arch is of two bricks or 18 inches in thickness; the span includes 2 feet on each side, occupied by brick drains, which are also 2 feet in depth.

The Sankey viaduct is the chief work of the kind on this railway, having nine arches of 50 feet span, principally built of brick with stone dressings and facings, the height from the surface of the canal-water to the level of rails being about 67 feet.

The Newton viaduct, consisting of four arches each of 30 feet span, and about 40 feet high to level of rails, may also be mentioned as worthy of notice. The whole width is 28 feet 2 inches, the height of parapets 3 feet 4 inches, and thickness 1 foot 4 inches.

The bridge over the river Irwell at Manchester has two stone arches, each 65 feet in span; and the railway is here about 30 feet above the water's surface. The width of this bridge is about 37 feet.

The width of railway between parapets of bridges is $25\frac{1}{2}$ feet, each of the side-spaces being $5\frac{1}{2}$ feet, and the intermediate space 5 feet 2 inches. The width of the Company's ground at Newton, where the Grand Junction Railway diverges, is about 50 feet, there being four lines of way. On the embankments, where there are side protecting banks, the whole width in the clear is 24 feet 6 inches. At Kenyon, where the Bolton Railway diverges, the railway, with three sets of rails, is 38 feet wide.

FENCING. — In some parts there are only two rails to the wooden fences, but as the quicks placed between the ditch and the railway are generally in a

very thriving state, this is of less consequence at the present time. The space occupied by the ditch, hedge, and post-and-rails fence, at Newton, near Warrington junction, is 4 yards, the ditch being 2 yards wide and 1 yard deep; the fence has three rails. In some parts stone walling is used instead of the ordinary wooden fence and quick.

The ballasting consists of broken stone, small coal mixed with earth, and small coal alone; which last is indeed the best description that can be used, being compact, yet sufficiently porous to admit of the free percolation of the water.

DRAINAGE.—The drainage throughout appears to be in excellent condition, and to answer its purpose thoroughly.

GAUGE, RAILS, &c.—The gauge is 4 feet 8½ inches, the intermediate space 5 feet 2 inches, and each of the side-spaces 5 feet 6 inches; thus the whole width of way is 25 feet 7 inches.

There are five different sections of rails used on this line, which are chiefly modifications of the double parallel form (see Plate III. figs. 30 to 37 inclusive). The heaviest weigh 75 lbs. to the yard lineal; then there are 70 lbs., 62 lbs., and 60 lbs. respectively, besides a few fish-bellied rails of 50 lbs. to the yard. The 75-lbs. and 70-lbs. rails have bearings of from 3 feet 9 inches to 5 feet; and the 62-lbs. and 60-lbs. have 3-foot bearings. Originally more than half of the line was furnished with blocks; those of red sandstone, however, being found split in several parts of the line, are being gradually removed, and larch sleepers substituted in their stead. The sleepers are from 8 to 9 feet in length, and have a scantling of 9 inches by 4½ inches, being half logs. The joint-chairs for the heaviest rails are 9½ inches long, and 6½ inches wide, and weigh each 26 lbs. Chairs of particular form are introduced for the meetings of rails of different sections. The rails are secured to the chairs by compressed wooden keys, the process of preparing which is described under “Crown Street Depôt.”

STATIONS AND DEPÔTS.—The principal stations are at Liverpool, Manchester, and Edgehill; besides which there are the following intermediate stations, viz. Broad Green, Roby Lane, Huyton Lane, Huyton Quarry, Ken-

drick's Cross, Lea Green, St. Helen's Junction, Collin's Green, Parkside, Kenyon Junction, Bury Lane, Flow Moss, Lamb's Cottage, Barton Moss, Patricroft, Eccles, and Cross Lane Bridge. Besides the above stations there are the following depôts, viz. those of Wapping and Crown Street, in Liverpool, and that adjoining the passenger-station at Manchester.

The locomotive engine-stations are at Edgehill, Liverpool, and between Ordsall Lane and Oldfield Road, Manchester.

LIVERPOOL PASSENGER-STATION.—The buildings composing the Liverpool passenger-station, which is stated to have cost 120,000*l.*, present a handsome elevation of stone next Lime Street. In this front there are two carriage-gateways for the arrival and departure of common-road carriages; the arrival-gateway being on the left, and the departure-gateway on the right of the railway.

There are four lines of way at this station, with intermediate spaces of 8 feet 4 inches each, and side-spaces of 2 feet 2 inches each, the whole being covered with light roofing, supported on cast-iron columns. The turn-tables are 11 feet in diameter and twelve in number, besides those in the building used for the construction and repairs of the carriages, which is two stories in height. In this building there are four lines of way, extending from end to end of the ground-floor; and by means of trap-ways in the upper floor, the bodies and other parts of carriages are readily raised and lowered from one to the other.

The booking-offices of the Company, and also those of the Grand Junction Company, are contiguous to each other, and on the left side of the railway; from the Haymarket there is a passage leading to the first and second-class booking-offices, as also to the booking-office of the Grand Junction Company.

The carriage-wharf is conveniently placed opposite the arrival-gate in the Haymarket, and near to the entrance of the carriage-department.

The goods-offices are on the right side of the departure-gate; and on the left side of the arrival-gate are the offices of the treasurer of this Company, and also of the treasurer of the Grand Junction Company.

The Edgehill station is situated at the upper end of the Lime Street tunnel, and extends from the mouth of the tunnel a distance of about 490

feet, the whole width being about 97 feet. The station is approached from Edgehill by two inclined carriage-roads, each 29 feet in width, the entrance-gates to which are fixed over and in a line with the face of the tunnel. The clear width of the open space at the face of the tunnel is 39 feet 6 inches, having a double way, which continues through the tunnel to Lime Street station; and two sidings, each about 100 yards in length, and communicating with the main way by means of traverses.

The buildings, which are here placed on each side of the line, are of uniform elevation, and consist of two engine-houses for the fixed engines, each 34 feet in length and 24 feet in width; a dwelling, which is occupied by W. Ralph, who attends the engines; a booking-office and waiting-room in one; a lamp-shop, and also porter's lodge and dwelling. The length of building on each side is upwards of 100 feet; but, excepting the engine-houses, which are situate at the east end, the width is only 18 feet.

The intermediate space at this station is 4 feet 10 inches, and the side-spaces each 1 foot 8½ inches. The stone platforms in front of the buildings are upwards of 19 feet in width, except where the engine-houses project; here the width is reduced to 13 feet.

The fixed engines, to work the Liverpool incline through the tunnel, are placed in the buildings already mentioned. These engines, which are in every respect similar to each other, were erected by Messrs. Mather, Dixon, and Co., and present a good specimen of the work produced at their establishment. The precaution of having two engines, in order to prevent a stoppage in the efficient working of this part of the line, in case of either being out of repair, is attended with considerable advantages, and is decidedly economical. The engines have each 25-inch cylinders and 6-feet stroke, and are worked ordinarily with a pressure of 40 lbs. on the square inch; the usual number of strokes in a minute is about twenty-six. The working-beam is 18 feet in length. The external dimensions of cylinders are 6 feet 9 inches in height and 30 inches in diameter.

The system of wheels for working the endless rope is arranged in vaults beneath the level of the railway. Arched passages afford convenient access to the several wheels, pipes, and machinery. The main shaft, on which is fixed the large rope-sheave, runs across from one engine to the other, and by means of a proper coupling, the machinery is easily put in motion

by either engine, as may be required. The large rope-sheave is of about 19 feet diameter ; the rim is formed with a groove about 10 inches in depth, to receive the 6-inch rope ; the thickness at junction with the arms is $6\frac{1}{4}$ inches, and its external depth $12\frac{1}{4}$ inches. The bed for the endless rope to run on is formed of five small ropes placed close together. The arms are eight in number, and each $2\frac{1}{4}$ inches thick. The rope is in contact with half of the wheel at a time ; and from the upper portion of the circumference passes out by a covered channel to the small sheeves fixed in the middle of one line of way. Over these sheeves, which are fixed at intervals of about 8 yards, it runs down through the tunnel to the Lime Street station, and passing half round a horizontal wheel fixed under ground, returns over the other line of sheeves back to the Edgehill station, where it passes round two 5-foot horizontal wheels placed in a recess below the surface of the way, in order to alter its direction. From these wheels it continues over sheeves on one side of a covered passage to a horizontal wheel of 4 feet diameter, which turns on the centre of the tightening-carriage. Passing half round this latter wheel, it is produced over a 5-foot vertical wheel to the groove of the large wheel ; thus forming an endless rope. Opposite to the station-buildings, the rope-channel is covered with a movable board, 13 inches wide and $\frac{3}{4}$ inch in thickness, let into grooves cut in the stone curb on either side. This channel is 10 inches wide and $8\frac{1}{2}$ inches deep, is built of brick, and paved with the same material.

To the front of the tightening-carriage, which runs on four small wheels on a pair of rails, one of which is placed on either side of the covered passage, a rope is attached, having a counter weight suspended at its other extremity in a well of about 60 feet in depth, the weight being immersed in water. At the top of the well the rope passes over a large pulley of $4\frac{1}{2}$ feet diameter. The tightening-carriage is of great use in keeping the rope stretched to its proper length, which varies considerably according to the state of the atmosphere. The signal for starting the engine is given by means of a pneumatic telegraph. These engines are supplied with steam from boilers fixed at the old tunnel station, the steam-pipe being carried in a small tunnel 5 feet wide and 5 feet high, so that it can be readily got at for repairs.

NEWTON STATION.—The first-class station at Newton, which is rather more than half way from Liverpool to Manchester, being $15\frac{1}{2}$ miles, is situate

close on the east side of the large viaduct at that place. It is approached by a sloped carriage-road, which, on our view of this line in November 1839, we found to be very steep; but which, we were informed, would shortly be altered.

On each side of the station is a small cottage-building, comprising a booking-office and waiting-room in one. The width between these buildings is 28 feet 2 inches. On the right of the way, going from Liverpool, there is a carriage-shed to hold two spare carriages. This building is 13 feet 8½ inches in the clear, and has a siding from the main line passing through it. There is a wooden turn-table, of 11 feet diameter, near to the carriage-shed. The urinals, which are four in number, and together 10 feet long, are enclosed with boarding 6 feet 2 inches high and 10 feet in length; the opening at each end being 2 feet 2 inches wide.

CROWN STREET DEPÔT.—Before the Lime Street tunnel was opened, the Liverpool passenger-station was at the present depôt in Crown Street, the management of which is entrusted to Mr. Gray. It is of itself, though only a very small portion of the Company's works, a considerable establishment. There is a smithy with thirty-six hearths, a spacious foundry, a boiler-maker's shop, a wagon-building and repairing shop, besides considerable space for coal-wagons, which are still brought here with coal for the supply of the upper part of the town. We were informed that there were not fewer than ninety men employed as smiths, strikers, boiler-makers, and spring-makers.

The smiths and boiler-makers earn from 33*s.* to 36*s.* a week; spring-makers, 34*s.* a week; strikers, 20*s.* a week, and upwards; and the foreman, 40*s.* a week. In the foundry thirteen men are employed, including three moulders, who each earn 30*s.* a week, and the labourers 18*s.* a week.

PREPARATION OF WOODEN KEYS.—The keys used for the various rails on this way are of oak, and are all compressed by means of a Bramah's hydrostatic press, which is fixed at this depôt. The oak before being compressed is dipped in palm-oil. The block through which the keys are passed is 15½ inches long, 13½ inches wide, and 9 inches high; the perforations being made of the particular gauge required. The keys are 6 inches in length, and for 62-lbs. rails are in their natural state, 2¼ inches square; but when re-

duced by compression are $2\frac{3}{8}$ inches by $2\frac{1}{2}$ inches. Another size is compressed from $2\frac{3}{8}$ inches to $2\frac{1}{2}$ inches. We were informed that four men could prepare 700 6-inch keys in a day.

The lathes and other machinery at this dépôt are set in motion by a small steam-engine.

There is a small tank here for kyanizing the sleepers and other timbers used on the works: it is 20 feet in length and 4 feet wide, and will hold 70 sleepers at a time. The sleepers, which are of larch, are generally 8 feet long, with a scantling of 8 inches by 5 inches.

From the top of the small tunnel to the gates in Crown Street there is a triple way, altogether about 30 feet in width and about 300 feet in length.

OLD TUNNEL-STATION ENGINES, LIVERPOOL.—The old engine-station, which is at the top of the Wapping and bottom of the Crown Street tunnels, is about 68 yards in length and 22 yards wide, independent of the recesses formed in the red sandstone rock on either side for the boilers, stable, &c.

The whole of the firing of the engines to work the Wapping and Crown Street tunnels, as well as the engines at Edgehill, is concentrated at this station. There are no fewer than eight large boilers erected for the use of the several fixed engines; two of which may be considered as extra spare boilers, to be used in case of repairs to any of the others. Some of these boilers are multi-tubular, having 3-inch tubes; and others have return fire-tubes. The usual working pressure is 40 lbs. on the square inch. Coke is mixed with the coal for the Wapping engine.

The engine-houses are situate on either side of the Moorish arch, and are 29 feet 5 inches apart, each 35 feet in length, and 18 feet in width externally. The engines have each 24-inch cylinders and 6-feet stroke; the usual pressure is stated to be 35 lbs., the working-beam is 13 feet 4 inches long, and the fly-wheel 20 feet in diameter.

For the Crown Street tunnel, the rope is wound on a roll 3 feet wide in the clear and 3 feet 4 inches in diameter; and for the Wapping tunnel an endless rope is used, with a tightening-carriage, as described for the Edgehill engines, but the large rope-wheel is fixed in a horizontal position, and is of 10 feet diameter; and there are two 5-feet horizontal wheels placed in the same line and between the large wheel and the tightening-carriage. The

rope passes twice round the large wheel, twice round the first 5-foot wheel, the centre of which is 11 feet from that of the large wheel, and once round the second 5-foot wheel. The well is 40 yards deep, and the bore below 60 yards additional. The counter-weight consists of a plate-iron bucket, which holds $2\frac{1}{2}$ tons of scrap-iron, and is 3 feet in diameter and 4 feet deep. There is also a small pumping-engine at this station, with 12-inch cylinder and $3\frac{1}{2}$ -feet stroke.

There are four men to attend these engines: the engine-men receive 30s. a week each, and the firemen 20s. The working-hours are from 6 A.M. to 6 P.M., with an allowance of two hours for meals.

From twelve to eighteen trains, of about twelve laden wagons each, are drawn up through the Crown Street tunnel daily. When the train reaches the top of the Crown Street tunnel Incline, the end of the rope is brought back by a small four-wheeled carriage, called a pilot, drawn by one horse; an operation which occupies about five minutes.

WAPPING DEPÔT. — Any one who is well acquainted with the streets of Liverpool, and is told that this depôt reaches from James Street, near Park Lane, down to the Quay of King's Dock, will have some idea of its extent. Most persons, however, will be better informed by the aid of figures. Its whole length, then, is something like 1200 feet; and breadth at Wapping about 140 feet, which, however, is the widest part: the area is about 2.66 acres. Full half of this space is occupied by warehouses.

From the foot of the tunnel two lines of way run quite down to the Quay of King's Dock, crossing Wapping on a level, and also Ironmonger Lane, which intersect the Company's property. From near the tunnel-mouth to near Wapping there are two additional lines; and between Wapping and Ironmonger Lane six lines of way. We estimate the total length of single way on this depôt at about one mile. We counted about eighty turn-tables; so that wagons may be moved in all directions, either in or out of the warehouses.

The entrance for road-carts and wagons is at Wapping; and from this street to within about 200 feet of the tunnel's entrance, there is a wharf for the whole length, with cranes conveniently placed for loading and unloading either the railway or road-wagons.

Close to the tunnel-mouth there are two weigh-bridges, also a weigh-house, stable, and lodge. Over the weigh-house are the offices, which are on a level with the street from Park Lane to Wapping. Here also is an inclined road from James Street to the railway specially used for driving down the Irish pigs, which are conveyed in large numbers along this railway. Close to this Incline a fixed engine has lately been erected, the particular use of which we were not able to learn.

The gauge or height for wagons laden with cotton at this depôt is 12 feet 5 inches: the uprights, which support the cross timber regulating the height, are 8 feet 3 inches apart.

We were informed that there are not fewer than 420 wagons in general use for merchandise.

Mr. Comber is the agent for the Company at this depôt: there is also an assistant and ten clerks. There are one hundred and thirty-three porters and check-clerks; four weighing porters; and three men to attend to the horses, which are five in number, and are used for conveying light goods to different parts of Liverpool. The goods for shipment are removed by the consignees. From 600 to 700 tons of goods are daily embarked on the railway from the Wapping depôt.*

MANCHESTER DEPÔT AND STATION.—The carrying-department of this Company is on a very extensive scale. At Manchester, the depôt and station are contiguous to each other. The station extends from the bridge over the river Irwell to the end of the carriage-shed, a length of about 550 feet. It has a triple way throughout, elevated on 22 brick arches, besides the bridge over Water Street, with an additional line opposite the departure-shed.

* The following are the rates of charge for the conveyance of merchandise, &c. between the termini, a distance of 30.66 miles:—Paving stones, 6s. 8d. per ton; stone, slates, timber, and deals, &c. 8s.; sugar, corn, grain, and flour, 9s.; dye-woods and lead, 8s. 4d.; iron, 7s. 6d.; cotton and manufactured goods, hides, drugs, and groceries, 10s.; other wool, 10s. to 11s. per ton; wines and spirits, 10s. 6d.; oil of vitriol in glass carboys, 2s. 6d. per can; glass and other hazardous goods, 14s.; cattle and pigs, 25s. per wagon (weight about 50 cwt.)—the owner at his own risk may put into the wagon as many as he pleases; sheep, 20s. a wagon; private carriages, four-wheeled, 20s. each; two-wheeled, 15s. each; horses by the coach-trains, one, 14s.; two, 20s.; and three, 24s.

The arrival-shed, which is on the left side as you approach Manchester, extends from the river Irwell to Water Street, a length of about 156 feet, and is 51 feet in depth, the front next the railway being open, with iron columns to support the roof at intervals of 13 feet. At the west end is a carriage-dock, where common road-carriages are taken off or embarked. An inclined road, about 36 feet wide, leads down to Water Street.

The departure-shed is on the other side of the way, and at the Manchester end of the station; it is but of small capacity, as it is only required to shelter passengers from the weather while getting into the carriages. The first and second-class booking-offices are on the level of the Liverpool Road; and the waiting-rooms, which are over, are on the same level as the railway, and are approached by wide staircases from the ground-floor.

The Grand Junction Company have also a general booking-office in the Liverpool Road, and a waiting-room above.

In this range of buildings are also included the house occupied by Mr. Green, the superintendent of the carrying-department at Manchester; the engineer's office, a workshop, and a shed to hold twenty carriages.

The arrangements for the arrival and departure of passengers are altogether very complete. Part of this station is carried over Water Street by a level beam-bridge, 40 feet in width, and about 15 feet high, the footways being separated from the carriage-way by nine cast-iron columns on each side: the carriage-way is 24 feet wide.

The depôt extends along the railway on the north side from Water Street to the eastern extremity of the Company's property, a distance of about 840 feet.

The stabling, with yard, occupies a considerable space, extending from the river Irwell to Water Street in one direction; and from the railway along the west side of Water Street, a length of about 190 feet, in the other direction. The stables, which extend under the arrival-shed, and also under part of the inclined road from Water Street, are arranged on two sides of the yard, which is approached by gates from Water Street. There are stalls for sixty-one horses, fifty-nine of which are at present occupied. Three horses are usually required for tracking at the station, and four or five for parcel-vans; there is also a collector's horse. The rest are required in the carrying-department for the town of Manchester. Under the inclined road there is

also a kitchen with a boiler and range, for the use of the men at the station, where they are allowed to have their meals.

The horses kept at this establishment have every appearance of being well taken care of: indeed, a knowledge of their treatment amply establishes the fact. They have three regular feeds a day; the first, which is at 6 A.M., consists of 10 lbs. of corn for each horse; the second, which is at 11.30 A.M., and the third at 5 P.M., consist of a mash made of clover, potatoes, turnips, and oats. The method of preparing this mash is as follows: a 1½-inch steam-pipe passes from the boiler of the engine used at the station into a mash steam-box, made of boiler-plate iron; this will hold about three sacks of vegetables, which being steamed for about half an hour, are afterwards put into a wooden-trough of about the same size as the mash-box, and mixed with clover, beans, and oats; the oats and beans being first crushed by the aid of the steam-engine. The preparation of the mash for one feed occupies two men about half an hour.

The vaults under the station are very commodious, but very damp; and appear to be chiefly used as stores for the vegetables. In one of the vaults is a hay-cutter, which consists of three segmental knives radiating from the axis of the machine. This apparatus is worked by a strap from the engine, and requires the attendance of a man and boy to cut from four to five trusses in an hour.

The warehouses of the Manchester depôt cover a large space of ground, and are generally three stories in height, besides the cellars. There are altogether three stacks of warehouses, the chief of which fronts the station opposite to the departure-shed, and extends along it for a length of about 320 feet, and averages about 70 feet in depth. Parallel to this, in the rear, and at a distance of about 60 feet, is the second stack, which is about 200 feet in length and 70 feet deep. The third stack is also about 200 feet in length and 90 feet in depth, and runs at right angles to the railway, and at a distance from the other stacks of about 75 feet. We estimate the area of warehouse-room in the several floors at about five acres, and the warehousing capacity at upwards of four millions of cubic feet.

On the floors of the first and third stacks, which are level with the railway, are laid cross lines of way, so that the wagons, by means of turn-tables, are conveyed and loaded, or unloaded, within the warehouses; and by loop-

holes next the warehouse-streets, and flaps in the floors, the arrangements for the quick despatch of business in this department are rendered exceedingly complete.

There are bridge-ways from the first to the second, and from the second to the third stack of warehouses, on the level of the railway. There is a large space of ground between the second stack of warehouses and Charles Street, belonging to the Company, at present unappropriated. The chief entrance for road-wagons to the warehouses is in Water Street, opposite to the stable-yard; and there is a way out under the railway into the Liverpool Road.

Besides the warehouses above described, there is a loading-warehouse, with proper wharf and cranes, and an inclined road up from the Liverpool Road. This building is about 225 feet in length along the Liverpool Road, and 42 feet in width. The front is next to the railway, which is here laid with three sets of rails; besides one line which runs within and along the whole length of this building.

Contiguous to this warehouse is the coal-depôt, which extends at right angles to the railway for a length of about 200 feet. Here there are five lines of way, two of which are placed over recesses, where the common-road wagons are loaded from the railway by means of trap-ways and coal-shoots, conveniently arranged. The road in front of the recesses is about 28 feet in width, and communicates at one end with the Liverpool Road, and at the other end with the street in continuation of Charles Street.

On the north side of the coal-depôt is a warehouse used by the Grand Junction Railway Company.

Altogether there is upwards of a mile of single way at the Manchester depôt and station, and more than sixty turn-tables. We mention all these particulars in order to shew the extent of accommodation necessary for a railway company who have the carrying-department in their own hands.

The whole area occupied by the depôts and station, including the unappropriated ground, is upwards of $4\frac{1}{2}$ acres.

For the use of the goods-depôt there is a steam-engine of 30-horse power.

The following will give some idea of the weekly expense of a small portion of this large establishment:—

Porter's Pay-bill (Manchester) for week ending November 22, 1839.

Warehouse-boys' wages	£4 11 0
Office-porters	6 17 0
Coal-station wages	5 16 0
Brakesmen	5 0 8
Watchmen	8 2 6
	<hr/>
	£30 7 2
	<hr/>

In the warehouses at Manchester there are about 110 porters, at wages of from 3s. to 4s. a day each.

LOCOMOTIVE-ENGINE DEPARTMENT, MANCHESTER DIVISION.—The locomotive-engine station for the Manchester division is situate at Salford, between Oldfield Road and Ordsall Lane, and on the south side of the railway. About twenty-eight locomotive engines are usually kept at this station. Here also the repairs of the locomotives are carried on to a considerable extent, there being, we were informed, not fewer than 120 men usually employed in this department.

In the office is kept a black board for each workman, with white figures corresponding with figures on the time-boards. On the black boards are letters corresponding with the days of the week; opposite to which, for each day, is set a mark if the man is at work, or if absent the mark is omitted. On the time-boards is noted down on what engine or engines each man has been engaged, and the result of each board is entered into a book daily.

The best fitters get from 4s. 6d. to 5s. a day, and lads beginning each earn 9d. a day. The lathes and other machinery are put in motion by a steam-engine of 6-horse power.

The working-hours of the men in the mechanical department are from 6 A.M. to 8 P.M., with an allowance of half an hour for breakfast, one hour for dinner, and half an hour for bagging (tea-time).

There are four tanks for the supply of the locomotives with water, which are fixed over the southern road-entrance to the Manchester station, and opposite to the arrival-shed. They are altogether 16½ feet long, 8 feet wide, and 7 feet high. A steam-pipe, of 5 inches diameter, passes from the boiler of the steam-engine to the under side of the tank, which is joined to a horizontal

pipe running the whole length of the tank, and from which four branches pass over the sides next the railway, and return down inside and across the bottom of the tanks. By this means the water is let into the tenders at a temperature of about 84° of Fahrenheit. The water which supplies these tanks is led by a 6-inch pipe from one of the mains of the Manchester water-works. Each tank holds about 9000 gallons of water, and is supplied to the Company at the rate of 9*d.* per 1000 gallons. The net weight of the tanks, which are made of $\frac{3}{4}$ -inch boiler-plates, is stated to be 2 $\frac{1}{2}$ tons.

The gauge to regulate the supply of water consists of a stone float, 20 inches square by 2 inches thick. The chain to which the float is attached passes over a pulley fixed on the top, and in front of the tank, next to Water Street; and by a metal index at the other end of the chain shews the depth of water on a vertical scale, graduated from 6 to 78 inches.

LIVERPOOL LOCOMOTIVE-ENGINE STATION, &c.—About thirty yards beyond the Edgehill passenger-station is the junction of the Liverpool goods and passenger-ways. From the Moorish arch at the old tunnel-station to the meeting of the lines at Edgehill, is a distance of about 440 yards. Here there are four lines of way, the width altogether being 40 feet 8 inches, and the intermediate spaces each 5 feet 3 inches. The whole width of way beyond the meeting of the lines is nearly 70 feet, there being four main lines, besides sidings and crossings.

The locomotive-engine repairing-shops are on the right side of the wide space at Edgehill; and are fitted up with lathes and other requisites in a very complete manner. About fifty men, including fitters and smiths, are said to be here employed; and there is a 12-horse engine for giving motion to the lathes and machinery throughout this department.

Opposite to the locomotive repairing-shop is a carriage-shed, about 420 feet in length and 30 feet in width, with a double way from end to end.

There is a water-tank and column near to the passenger-station at Edgehill, and an engine turn-table 14 feet 6 inches in diameter; and on the opposite side three carriage turn-tables.

At the bottom of the Sutton incline is an engine-house for two assistant locomotives, called bank-engines, which are of considerable power; having 14-inch cylinders and 20-inch stroke, and two pair of 5-feet coupled wheels.

LOCOMOTIVE ENGINES.—The proportions of the engines belonging to this Company are tabulated at pages 17, 18, and 19 of the Appendix, as well as of those originally introduced on this line by Messrs. Rt. Stephenson and Co. of Newcastle.

Both the Worsley and Hulton's cokes are supplied at 25s. a ton.

CARRIAGE DEPARTMENT.—The carriages used on this line are of three kinds, viz. mails, and first and second-class carriages. The mails are in three compartments, and will hold altogether twelve persons. The first-class carriages are also in three compartments, and will hold eighteen passengers each. They are generally designated by names, as Delight, Greyhound, Harlequin, &c. The second-class carriages are also in three compartments, and will hold altogether twenty-four passengers. They are open at each side, but closed at the ends, and have a roof from end to end. The wheels used for the carriages are generally of cast iron, with wrought tires, and are of 3 feet diameter; but wooden wheels are once more being used for the carriages on this line.

All the mails and first-class carriages are furnished with spring buffers; the insides are lined with drab cloth, and the cushions properly stuffed with horse-hair; the seats are separated by elbows, by which each passenger gets his full share of room.

The dimensions of a horse-box are as follows: length, including buffers, 12 feet 3½ inches; length of the box 9½ feet, width 7 feet 7 inches, height 7 feet 5 inches. The side-flaps, which are hung vertically, are in two heights, the lower one being 3 feet 6 inches wide, framed with four vertical outside ledges. The under side of soles is 20 inches above the level of rails. The wheels are of 3 feet diameter, and the distance between centre and centre of axles 5 feet. One pair is of wood, and the other of cast iron with wrought tires.

WAGONS.—There are about 428 wagons and trucks for goods, generally having cast-iron wheels with wrought tires. The net weight of trucks is from 30 cwt. to 42 cwt. each. The gauge for wagons laden with cotton is 12 feet 5 inches high by 8 feet 3 inches wide.

When timber is to be conveyed on the railway, it is placed on two trucks

properly built for this purpose. Above the ordinary truck-platform are fixed cross pieces of timber, curved towards the middle, which is higher than the sides by about 2 inches; above these are cross-timbers 12 inches by 8 inches, and curved upwards as to their ends, which are 4 inches above the fixed cross-pieces. Each of these pieces turns on a swivel fixed in the middle of the cross-timber. This arrangement allows the wagons to have proper play in going round curves. Chains are used to secure the logs to the carriages. We observed one log of timber placed on two trucks, which was upwards of 50 feet in length.

Mr. Hulton's coke-wagons, which pass frequently on this line, average each 2 tons net weight, and carry 4 tons of coke. The wheels are of cast iron and 3 feet in diameter, with outside bearings; the axles being of $3\frac{1}{4}$ inches diameter.

Some of the wooden coal-wagons which we found at the Manchester coal-depôt are 10 feet in length, 3 feet 9 inches wide, and 1 foot high. The bottom is $1\frac{1}{2}$ inches, and the sides are $1\frac{1}{2}$ inches thick. The wheels are of cast iron, 3 feet diameter, and 4 feet 8 inches from centre to centre of axles. The gross weight of one of these wagons is 5 tons 17 cwt. 2 qrs. There is a flat iron draw-bar running underneath the bottom from end to end; and each wagon is furnished with three stout draw-chains.

TRAINS, FARES, PASSENGERS, &c.—There are six merchandise-trains daily in each direction, and eleven passenger-trains. Of these the seven, nine, quarter-past-eleven, A.M., two, five, and half-past-seven, P.M., are mixed first-class trains; the rest, viz. half-past-seven, ten, quarter-before-twelve, A.M., and quarter-before-three and half-past-five, P.M., are second-class trains.

The first-class train generally consists of five carriages. The second-class train at half-past-seven, A.M., consists of from eight to ten carriages, including two for Preston, which are left for the North Union train at Park-side. The ten o'clock mixed second-class train has generally two first and four second-class carriages. The quarter-before-twelve train consists usually of eight carriages, including sometimes one, sometimes two first-class carriages. The quarter-before-three afternoon-train is usually made up of ten carriages, including two first-class.

At the Manchester station the horn blows every time a train arrives or departs. The tickets are taken at the commencement of the journey.

A paper is given to each engine-driver on his departure with a train, on which is noted down his own name and the name of the fireman, the name of the engine, the time of starting, and the number of coaches, trucks, and laden wagons, of which the train is made up. This paper is delivered by the driver to the time-keeper, on the arrival of the train at its destination. The time-keeper notes down on a paper, which is delivered to the Board weekly, the date, train, time of starting, time of arrival, name of engine and driver, with any observations that may be necessary. It is his duty also to note down the exact time of departure of each train, as also the names of the engine and driver.

The goods going by the merchandise-trains are all weighed at the depôt before being put into the wagons.

The total number of passengers conveyed on this line from the 2d of June, 1838, to 6th January, 1840, was 1,323,947, or at the rate of 1801·28 per diem. From 2d January, 1838, to 6th May, 1839, inclusive, the receipts per diem on account of passengers, parcels, &c., amounted on an average to 331*l.* 5*s.* 7*d.*; and from the 7th May, 1839, to 6th January, 1840, the receipts on account of passengers only amounted, on an average, to 390*l.* 8*s.* 1½*d.* per diem. The proportion of second to first-class passengers was as 1·062 to 1.

The present fare for a mail-passenger between Liverpool and Manchester is 6*s.* 6*d.*; for a first-class passenger, 6*s.*; and for a second-class passenger, 4*s.* 6*d.*; being respectively at the rates of 2·544*d.*, 2·348*d.*, and 1·761*d.* per mile.

For the first four months of this line being opened, the fare for a first-class passenger was 7*s.*; and for a second-class passenger 3*s.* 6*d.* The mails were then introduced on the line, and the fares for the three classes of carriages were 6*s.*, 5*s.*, and 3*s.* 6*d.* respectively. From 10th October, 1832, when the passenger-duty was imposed, the fares were raised to 6*s.* 6*d.*, 5*s.* 6*d.*, and 4*s.*

The present rates of charge for passengers, as stated above, were not introduced until after the opening of the line into the centre of Liverpool, by means of the Lime Street tunnel. This extension is of the utmost use to the travelling public generally, but particularly to those merchants and manufacturers of Liverpool and Manchester, who are backwards and forwards on the line every week.

The Grand Junction Railway Company, under a special contract with

this Company, pay 1*s.* per passenger, and 2*s.* per ton for goods, conveyed in their own carriages, for the use of the line between Newton and Liverpool and Newton and Manchester; but this toll, however, entitles them to the use of the passenger-stations, to a booking-office at Liverpool and Manchester, and to the use of the stationary-engine power at Liverpool, &c.

In the years 1837, 1838, and 1839, the gross receipts for the conveyance of passengers, goods, and tolls, amounted to 755,865*l.*, or at the rate of 251,955*l.* per annum.

We found the average weight of twenty-eight trains to be 55,343 lbs.; the average velocity to be at the rate of 23·93 miles an hour; the highest velocity 50 miles an hour; and the stoppages to average each 1·50 minutes (see Table H. of Results of Practical Experiments in Appendix).

SIGNALS AND REGULATIONS.—The following code of signals and regulations, adopted on the Liverpool and Manchester Railway, may serve as a guide to other Companies.

BY NIGHT.—The *white* light stationary indicates that all is right; but if waved *up* and *down*, is a signal to stop; if waved *to* and *fro* sideways, to proceed cautiously. The *red* light is a signal always to stop. The *green* light is a signal that a necessity exists to proceed slowly and cautiously; and if used at Newton Junction, it indicates that the points are set open for going towards Warrington.

BY DAY.—The *red* flag is the signal to stop. The *blue* flag is to stop luggage or picking up trains for the purpose of sending on wagons. The *black* flag is used by plate-layers to indicate that the road is undergoing repair, and that trains must pass slowly. It is to be understood that any flag or lamp, of whatever colour, *violently waved*, is a signal to stop.

REGULATIONS.—1. Every train on the railway shall shew a red bull's eye, or reflector-lamp, on the last carriage or wagon, and the guards of the coach-trains, the brakemen of the luggage-trains, and the fireman of an empty engine, or, with a wagon-train without a brakeman, shall see to, and be held responsible for, the execution of this order; and if a coach, or truck, or horse-box, or wagon, be attached to, or detached from, a train on any part of the road, the guard, or brakeman, or fireman, shall immediately change and replace the red bull's eye, or reflector-lamp, so that the same may still be in the rear of the last carriage or wagon in the train.

2. Every engine shall carry at least one effective bull's eye, or reflector-lamp (with a white light), in front of the engine; and every engine belonging to the Grand Junction Railway Company shall carry two such lamps on the front buffer-plank while on the Liverpool and Manchester Railway.

3. Every engine-tender to carry a lamp so fixed as to admit of being turned round, exhi-

biting a white light forward and a red light backward, in whichever direction the engine may be moving.

4. Every gateman or policeman shall light his gate or station-lamp at dusk, and shall have his hand-lamp constantly trimmed and burning, and ready to give such signals as may be required.

5. If a coming engine or train be required to stop to take up passengers, a red light must be shewn in the gate-lamp.

6. If a train approaches when a previous train has passed through only a few minutes before, the gateman shall signify this circumstance to the engineman by the waving of his hand-lamp *to* and *fro*, *sideways*, which means that caution is required; on which signal all enginemen are required to go slowly, and keep a good look-out.

7. But if a gateman, owing to an accident, or any other extraordinary cause, wishes to stop an engine which is approaching, he must not only shew his red light, but wave his hand-lamp *up* and *down*, up to the height of his head and then down to the ground, till the engine comes up; and all enginemen are required to stop at this signal being given; and a gateman will be right in making this signal to an approaching engine, if a previous engine has passed through his gate only three or four minutes before.

8. *Rules to be observed during a Fog, or in Thick Weather.*—Whenever a coach-train stops at any of the stations, or places for taking up or setting down passengers (during a fog, or in thick weather), the gateman or policeman of the station shall immediately run 400 yards behind the train, or so far as may be necessary to warn any coming engine, in order to prevent its running against the other; and all enginemen shall slacken speed in foggy weather, and proceed at a slow pace at an ample distance from trains as they approach each of the stations and stopping-places, in order that they may have the complete control of, and be able to stop, their engines and trains without risk of running against any train which may happen to be waiting at such station or stopping-place. And in case any engine (whether with coaches or luggage-wagons, or without,) shall stop, in foggy or thick weather, in any part of the road where there shall be no gatemen or policemen, and where there shall be no plate-layer, to render assistance, the fireman shall immediately run back 400 yards, or so far as may be necessary, to warn and stop any other engine coming in the same direction; and all enginemen, firemen, and guards, shall be held responsible that these orders be strictly complied with in respect of any train (circumstanced as above) to which they may severally belong; and they shall report to the Directors any gateman, fireman, or plate-layer, who shall refuse or neglect to use the precautions hereby ordered to be rigidly adopted.

In foggy weather enginemen are cautioned to make frequent use of their steam-whistle when they approach any station; also whenever they are obliged to stop on the road, or when, from any cause, they are obliged to go slower than usual, in order to prevent accidents from trains which may be following on the same line.

All gatemen, plate-layers, and policemen, shall render every assistance in their power in case of accidents, or in foggy weather; and shall attend to, and obey the regulations hereinbefore ordered to be observed.

Local Signals and Rules to be observed.—Any engine or train being obliged to stop in or near the curve in Olive Mount cutting, a man must instantly go back 400 yards to warn any train coming forward on the same line.

FOOT OF WHISTON INCLINE AND HUYTON QUARRY.

To be observed by Enginemen, Firemen, Guards, and Brakesmen, on approaching this place.

If coming from Huyton Gate. — 1. The red flag hoisted on the pole close to the Company's cottages is the signal for second-class trains to stop to take up passengers. The red lamp opposite the cottages is the corresponding signal at night.

2. The red flag hoisted on the pole *north side* of the railway, opposite Baker's Marble Works, is the signal that there is some obstruction on the north main line of railway, and that trains coming from Liverpool must stop. The red lamp at the same place is the corresponding signal at night. These two signals may be seen almost immediately after passing Huyton gates.

If coming down Whiston Incline. — 3. The red flag hoisted on the pole at the Bank engine-shed is the signal that there is some obstruction on the south main line of railway, and that trains coming down the Incline must stop. The red lamp at the same place is the corresponding signal at night. These two signals may be seen from Platt's Bridge.

4. Policemen are required to make the above signals in conformity with the directions given to enginemen and others. The policeman at the Bank engine-shed and the policeman at the Marble Works must warn each other of the necessity of stopping any coming train by means of the two poles with red flags, and the two posts with red lamps, which have been erected on the south side of the railway for that purpose. This regulation must be strictly attended to, so as to prevent accidents to trains passing round the curves at Huyton Quarry, where enginemen can only see a short distance ahead.

5. All enginemen, whether with Liverpool and Manchester, Grand Junction, or other trains, are required to give one loud whistle, as they pass "Platt's Bridge" in coming down Whiston Incline, for the purpose of making the policemen at the bottom aware of their approach. "Platt's Bridge" is the bridge nearest the foot of the plane, where a road crosses over the railway.

NEWTON JUNCTION.

6. By night, a green light visible from either of the Liverpool and Manchester main lines denotes that the points are open for trains going towards Warrington. By day, a gilt arrow pointed towards Warrington is the corresponding signal.

7. Signal-posts chequered red and white have been placed at the points leading off the Liverpool and Manchester on to the Grand Junction Railway. Whenever the chequered sides of these boards are presented to face trains coming from Liverpool, or Manchester, or Warrington, it is the signal that a passenger-train has immediately preceded them; and enginemen are therefore required to proceed with additional caution. Policemen must always make the proper signals.

N.B. These boards are visible by night as well as by day.

8. The Grand Junction Railway Company have had a lamp-post put up at Newton Junction provided with a red lamp, which is hoisted in the night whenever any of the Grand Junction trains are near the top of the Incline, to give notice to enginemen on the Liverpool and Manchester Railway that such is the case; so that, if necessary, they will be able to stop before coming to the crossing. The light is on the south side of the Liverpool and Manchester line, and can be seen from the Sankey viaduct and from Newton bridge.

N.B. For sundry rules and regulations, see Rules and Regulation-book, which, as well as this Code of Signals, all enginemen, guards, and policemen, are required to carry constantly with them.

Liverpool, 10th October, 1839.

PERMANENT WAY.—For the second and third years after the line was opened, Mr. James Scott contracted to keep the way in order for the sum of 250*l.* per mile per annum. At present it is under the Company's own management, who have a superintendent from Manchester to Newton under Mr. Edward Woods, the resident engineer on the Manchester division, and another from Newton to Liverpool under Mr. Scott, Jun., the resident engineer on the Liverpool division. The latter gentleman informed us that rather more than 3½ men per mile were required to keep the way in order.

RECEIPTS AND EXPENDITURE.—The total receipts for the year 1839 amounted to 269,562*l.*, and the disbursements for the same period to 158,382*l.* 2*s.* 1*d.*, being at the rate of 58·73*l.* per cent on the gross revenue. The receipts for the half year ending 30th June, 1840, amounted to 126,474*l.* 9*s.* 8*d.*; and the expenditure for the same period to 67,003*l.* 5*s.* 1*d.*, the net profit being 59,471*l.* 4*s.* 7*d.*, or 4·203*l.* per cent on 1,414,807*l.* 10*s.*, the present capital in shares and loans.

The construction of the way and works up to 30th June, 1840, amounted to 1,407,172*l.* 19*s.* 1*d.* instead of 1,224,000*l.*, as stated in p. 187, which was the amount to a previous date.

That the estimate of the cost of this railway should have been so much exceeded is not to be wondered at, when it is considered of how novel a character were the works and necessary arrangements throughout. This line was laid out, and the works were constructed, under the direction of Mr. Stephenson.*

The following salutary rules and regulations are worthy the attention of the directors and managers of other railways:—

1. *Orders to Enginemen and Firemen.*

That no locomotive steam-engine shall pass along the wrong line of road, that is, along the south line of the railway in going towards Manchester, or along the north line of railway in going

* Mr. William James was the original projector of the Liverpool and Manchester Railway; and the first parliamentary documents were prepared under the direction of Messrs. G. and J. Rennie.

towards Liverpool; and every engineman and every fireman shall stand up and keep a good look-out all the time the engine is in motion, except as to such fireman only when he shall be otherwise engaged about his other duties on the engine or tender. And that no person, except the proper engineman, and his proper fireman, shall be allowed to ride on any locomotive steam-engine or tender without the special license of the Directors, or of the engineer of the Company, for the particular purpose and occasion previously obtained from time to time.

2. That if, in case of accident, any engine shall be unavoidably obliged to pass back on the wrong line of road, the engineman shall always send his assistant, or some other person, back beyond the nearest stopping-place or shunt before the engine moves backward, to warn any engine coming in the opposite direction; and if dark, the man who goes back in advance of a returning engine shall be ordered to take, and shall take a light, to make a signal by waving the same *up* and *down* to any coming engine to stop; and that the engineman of the engine moving on the wrong line shall make a constant use of the steam-whistle, and must not move in the wrong direction farther than to the nearest shunt; and, being arrived there, shall proceed instantly to remove the engine off the wrong line of road. These precautions must on no account whatever be neglected.

3. Every engineman shall have with him at all times in his tender the following tools; and in the event of any of them being lost, he shall immediately get the same replaced, viz.: — A complete set of screw-keys, one large and one small monkey-wrench, three cold chisels and a hand-hammer, one crow-bar, one long chain and two short coupling-chains with hooks, two spare ball-clacks, a quantity of flax, gaskin, and string for packing, &c.; oil-cans, large and small plugs for tubes.

N.B. The engineman to be responsible for the above tools.

4. That all engines travelling in the same direction shall keep 600 yards at least apart from each other, that is to say, the engine which follows shall not approach within 600 yards of the engine which goes before; and in coming down either of the inclined planes the following engine shall not come within 900 yards of the train which precedes it.

5. That no engineman shall, at any time or under any circumstances, leave his engine or train, or any part of his train, either on the inclined plane or elsewhere, without placing a man in charge of the same to cause the proper signals to be made to prevent other engines from running against them.

6. That all enginemen having charge of goods or luggage-trains shall always exert themselves to keep out of the way of coach-trains by shunting, if necessary; and if doubtful of getting out of the way of a coach-train, shall direct the gatemen and plate-layers to make signal to coach-trains that a luggage-train is before them.

7. That no engine, carriage, or wagon, or train of carriages or wagons, whether loaded or unloaded, shall (except only in the case of absolute necessity, as to prevent accident or collision) stop upon the line of any highway so as to interrupt the passing along such highway or public-road, whether the same be at or near to any of the stopping-places on the railway or not, under the penalty of ten shillings upon every engineman, fireman, guard, or other person, having the charge of such engine, wagon, or train, for every such offence from time to time.

8. That no luggage-train shall pass any station or stopping-place whilst a coach-train is

stopped, or in the act of stopping on the other line of road, there to take up or set down passengers.

9. That, in approaching any station or stopping-place at any part of the line of railway, every engineman or other person having charge of any engine, carriage, wagon, or train, whether loaded or not, shall, at ample and sufficient distance, slacken his speed, and approach at such a moderate speed as will enable the engineman to stop the engine or train promptly, and without the danger of a concussion or other accident.

10. That whenever and wherever a signal to stop is made by any policeman or other person, namely, when the flag is hoisted or held out, or a red light is shewn, or lantern waved up and down, especially at or near to the bottom of any inclined plane, every engineman shall always stop, whether he can take up any other passenger, or carriage, or wagon, or not (or whether he comprehends the reason for the signal being made or not), because the signal may be made on some account of which he is not aware; and serious accidents may happen for want of attending to the same.

11. That no engine shall be allowed to propel before it a train of carriages or wagons, but shall in all cases draw the same after it, except when assisting up the inclined plane, or in case of any engine being disabled on the road, when the succeeding engine may propel the train slowly as far as the next shunt or turn-out, at which place the said propelling engine shall take the lead.

12. That, in the event of the road or passage being obscured by steam or smoke (owing to a burst tube, or from any other cause,) any engine or train coming up shall not pass through the steam or smoke, but the engineman shall stop at a sufficient distance to prevent collision, and shall ascertain that the way is clear and safe before attempting to proceed. And that if any coach-train shall have stopped, or be stopping, whether from accident or other cause, on the opposite line of the railway, every engineman, and other person having charge of an engine, approaching the same, shall immediately slacken his speed, so that he may pass the halting or opposite train slowly, or stop his engine entirely, if necessary, at an ample distance before reaching it.

13. Some of the enginemen having doubted whether the practice of changing engines (half way) on Sundays was by *order*, or by *permission*; notice is given that the enginemen are required to change (half way) on Sundays, unless by mutual agreement and consent each engineman remains with his own engine.

14. The Directors having been informed that the second-class coach-trains frequently stop to the westward of the Broad Green Road, notwithstanding the order that they are to stop between Thomas's Lane and Broad Green Road, the enginemen are informed that they will subject themselves to fines if they stop the trains otherwise than as above directed. The enginemen are also cautioned not to spill so much coke on the road.

15. If any engine shall get off the rails, or meet with any other accident, the engineman shall report the same with particulars without loss of time to one of the engineers, or to the Company's foreman, Mr. Melling at Liverpool, or Mr. Fyfe at Manchester; and in case any accident whatever happen to an engine, and the circumstances be not immediately made known as here directed, both engineman and fireman of such engine shall be fined at the discretion of the Directors.

16. Information having been received by the Directors that certain of the enginemen disregard the signals of the plate-layers when it is necessary that the engine should stop, or go slowly

over rails newly laid or under repair, notice is given that the plate-layers are ordered to report the names of the enginemen who shall in future disregard their signals; and such enginemen will incur the severe displeasure of the Directors.

17. If any engine has to pass along the road after ten at night, or before five in the morning, the fireman, if necessary, must open the gates; and he and the engineman will be held responsible for any damage done to the gates through any neglect.

18. Complaints having occasionally been made that the coach-trains are delayed by luggage-trains on the way, enginemen are hereby strictly ordered when likely to be overtaken by coach-trains, whether Grand Junction or Liverpool and Manchester, to shunt their luggage-trains in good time, and wait in the siding till the coach-train shall have passed.

19. No goods are to be taken along the line without being completely *sheeted*, if they be of such a nature that they can take fire by a spark or hot cinder from an engine. And enginemen are hereby ordered to refuse to take up such description of loads at the different stopping-places unless completely sheeted.

20. A wagon-load of cotton having taken fire, being the first wagon in the train next the engine, enginemen are required to take notice that two or more wagons (not loaded with cotton) are always to be placed next the engine, otherwise not to proceed with the train, unless with special and distinct orders to that effect from the Company's superintendent at the luggage-station, Edge Hill. In returning from Manchester there must always be three or more empty wagons next the engine.

21. *Speed of Travelling.*

Notice is given that during the winter months, namely, during the months of November, December, January, and February, the time for performing the trip between Edge Hill and Manchester with first-class coach-trains is one hour and a half, and with second-class trains two hours. And that during the remainder of the year the time for performing the trip with the first-class trains is one hour and a quarter, and with second-class trains one hour and three-quarters, except in foggy weather and in the dark, when the speed must be slower; the time to be taken for the trip being, in such cases, one hour and a half first-class, and two hours second-class, the same as in the winter months. And all enginemen are required to regulate the speed of their engines as accurately as practicable, according to the times specified under the several circumstances above stated.

22. Engines with light loads being sometimes driven at a very great and unnecessary speed, notice is given that enginemen persisting in so injurious a practice will be fined. Engines with luggage or empty carriages should not exceed a speed of twenty miles an hour without some necessity in the case.

23. *Rules to be observed in the use of Signal-Lamps after Dark.*

That every train on the railway shall shew a red bull's eye, or reflector-lamp, on the last carriage or wagon; and that the guards of the coach-trains, and the brakemen of the luggage-trains, shall see to, and be held responsible for, the execution of this order; and if a coach or wagon be attached to, or detached from, a train on any part of the road, the guard or brakeman shall

immediately change and replace the red bull's eye, or reflector-lamp, so that the same may still be in the rear of the last carriage or wagon in the train. And moreover, that every engine shall carry at least one effective bull's eye, or reflector-lamp (with a white light), in front of the engine; and that the engines of the Grand Junction Railway Company shall carry two such lamps on their front buffer-plank while on the Liverpool and Manchester Railway.

24. Rules to be observed in passing the Inclined Planes.

The assistant-engines shall invariably return down the left-hand line; and no luggage-engine shall leave any part of her load on the main line at the bottom of the Incline, provided the assistant-engine be there; but if the assistant-engine be not there, or not ready, the luggage-engineman may leave part of his load at the bottom of the Incline, and return down the same line, provided that by so doing he will not impede any coach-train that may be following; and provided also that he places a man in charge of the wagons so left to go 400 yards behind, to warn any coming train that the way is not clear. If there be reason to expect a coach-train, the engineman must shunt at the bottom so many of his wagons as he cannot take up; and having shunted the remainder at the top, must return on the proper down line.

25. In the event of any wagon being left upon, or at the foot of, the Incline, and a succeeding engine coming up, such succeeding engine shall not commence propelling or drawing the said wagons until the engine which has left them there shall have returned.

26. Complaints having reached the Directors that the helping-engines are very slow in starting to follow the coach-train up the bank, the enginemen are ordered to be ready, on the signal being given, to follow the trains immediately after they pass, otherwise they will be fined for neglect of duty.

27. That no engine, either with or without passengers, coals, goods, or luggage, shall go down any of the inclined planes at a greater speed than from twenty to twenty-five miles per hour; and that no engineman shall attempt to make up lost time in going down any inclined plane; and coming down Whiston Incline, no engineman shall begin to increase his speed till he gets to Huyton Quarry station.

28. That, in going down any inclined plane, every engineman, or other person having charge of a luggage-train, shall take care that he has full and complete control over the speed of his train, by pinning down, or causing to be pinned down, his wagon-brakes, fewer or more according to the size or weight of the train, whether there be a luggage-brakesman with the train or not; and that in case of accident for want of this proper control over the speed, the engineman shall be held responsible. And the policemen at the top of the Inclines shall, and are hereby charged to, assist in pinning down the brakes when desired so to do by the engineman of the train.

29. All enginemen, whether with Liverpool and Manchester, Grand Junction, or other trains, are required to give one loud whistle as they pass "Platt's Bridge" in coming down Whiston inclined plane, for the purpose of giving the policeman at the bottom effectual and timely notice of their approach. "Platt's Bridge" is the bridge nearest the bottom of the Incline.

30. Enginemen with trains requiring assistance up the inclined planes are required, in all cases, to go up the bank first, and let the assistant-engine follow after. And all bank-enginemen are hereby strictly ordered never to go before a train, but to follow carefully after; not starting from

the siding till the last wagon or carriage in the train shall have passed the points of junction on the main-line; but then to follow immediately, and assist the train to the top of the inclined plane, but no further.

31. Notice to Enginemen with Ballast-Trains.

The Directors hereby give notice, that when any ballast-train shall stop on the main-line to discharge or take in ballast, or blocks, or sleepers, or any other materials, the engineman shall send the fireman or one of the ballast-men four hundred yards back, with a signal flag, to stop any coming train, and the man shall there remain on the look-out, till the ballast-train is ready to move.

32. Rules to be observed during a Fog, or in Thick Weather.

That whenever a coach-train stops at any of the stations or places for taking up or setting down passengers (during a fog or in thick weather), the gateman or policeman of the station shall immediately run 400 yards behind the train, or so far as may be necessary, to warn any coming engine, in order to prevent its running against the other; and that all enginemen shall slacken speed in foggy weather, and proceed at a slow pace at an ample distance from, and as they approach each of the stations and stopping places, in order that they may have the complete control of, and be able to stop their engines and trains without risk of running against any train which may happen to be waiting at such station or stopping place. And that, in case any engine (whether with coaches or luggage-wagons, or without) shall stop, in foggy or thick weather, in any part of the road where there shall be no gatemen or policemen, and where there shall be no plate-layer to render assistance, the fireman shall immediately run back 400 yards, or so far as may be necessary to warn and stop any other engine coming in the same direction. And that all enginemen, firemen, and guards, shall be held responsible that these orders be strictly complied with, in respect of any train (circumstanced as above) to which they may severally belong; and they shall report to the Directors any gateman, fireman, or plate-layer, who shall refuse or neglect to use the precaution hereby ordered to be rigidly adopted. In foggy weather, enginemen are cautioned to make frequent use of their steam-whistle when they approach any station; also whenever they are obliged to stop on the road, or when, from any cause, they are obliged to go slower than usual, in order to prevent accidents from trains which may be following on the same line.

33. Orders to Gatemen and Policemen.

That all gatemen and policemen shall be constantly on the look-out, and shall open the proper gate when an engine has to pass through.

34. That all gatemen and policemen shall render every assistance in their power, in case of accidents, or in foggy weather, and shall attend to, and obey the regulations herein before ordered to be observed in foggy weather. (See No. 32.)

35. That all gatemen shall communicate to the enginemen passing through the gates, verbally or by signs, if caution is required from the engineman as he proceeds.

36. That every gateman shall light his gate-lamp at dusk, and shall have his hand-lamp constantly trimmed and burning, and ready to give such signals as may be required.

37. That if a coming engine or train be required to stop to take up passengers, a red light must be shewn in the gate-lamp; and if the coming engine or train is not required to stop, the common white light shall be shewn.

38. That if a train approaches, when a previous train has passed through only a few minutes before, the gateman shall signify this circumstance to the engineman, by the waving of his hand-lamp to and fro sideways, which means that caution is required; on which signal, all enginemen are required to go slowly, and keep a good look-out.

39. But if a gateman, owing to an accident, or for any other extraordinary cause, wishes to stop an engine which is approaching, he must not only shew his red light, but waive his hand-lamp conspicuously *up* and *down*, up to the height of his head and then down to the ground, till the engine comes up; and all enginemen are required to stop on this signal being given. And a gateman will be right in making this signal to an approaching engine, if a previous engine has passed through his gate only three or four minutes before.

40. All policemen and gatemen are required when a luggage-train approaches their several stations, and before she comes up, to go on the line, and inspect both sides of the train, to ascertain whether any of the loading (particularly bags of cotton), have slipped so as to over-hang the wagon more than when first loaded; and if such be the case, to make immediate signal for the train to stop, in order that the loading may be put right, and fastened on again, before the train proceeds.

41. *Rule to be observed at Newton Junction.*

That all trains passing to or from the Liverpool and Manchester and the Grand Junction Railways shall slacken speed, so that the same shall not exceed fifteen miles an hour, before passing from one line to the other.

42. If, when any second-class train has arrived at the Warrington Junction, a Birmingham train is seen coming up the Warrington inclined plane, the engineman must stop, and allow the Birmingham-train to pass before him, either to Liverpool or to Manchester. Also, if the Birmingham coach-train overtake a Liverpool and Manchester second-class train more than three miles distant from Liverpool or Manchester, the second-class train must shunt, if there be an opportunity, to allow the Birmingham-train to pass.

43. *Brakesmen's Orders.*

Considerable damage having been done to goods conveyed by railway by fire, before the brakesmen or enginemen were aware of the danger, the brakesman to the train is hereby required to ride on the last wagon, and keep a good look-out, under pain of dismissal for neglect of this order.

44. The wagon-sheets having been much injured by being trampled on by the brakesmen running over the wagons; notice is given, that (unless in case of some sudden emergency) the brakesmen are forbidden to pass over the loaded wagons, to the unavoidable injury of the sheets; and that for disobedience to this order they will subject themselves to fines or dismissal.

45. It is ordered that the brakesman going to and from Manchester be held responsible for a proper supply of signal-lamps at each end of the line; also the brakesmen are required (and the firemen when there are no brakesmen) to take the lamps off the trains when they arrive at their destination, and deliver them into the store.

46. *General Orders.*

Whenever an engine takes out more than three empty coal or other wagons to the bottom of Whiston Incline, they are to be put into the siding by the engine; when not more than three wagons are left, they may be shunted by the policeman.

47. When any wagons of goods are left on the road, which should have been brought on to Liverpool, the engineman and fireman are to give information of the same, on arrival, to the Company's superintendents at Liverpool or Manchester.

48. Considerable damage having been done to the large turn-rails, by the careless manner in which the engines and tenders are turned, by being jerked round too suddenly; engine-turners, enginemen, and firemen are hereby cautioned to be more careful in future; and those who neglect this caution will be fined.

49. Many wagon draw-chains having been broken by the violent starting, or sudden increase of speed of the engines; the enginemen are hereby cautioned to use more care in this respect, especially at the top and bottom of the inclined planes.

50. *Old Tunnel Mouth. General Order.*

Coal-wagons must never be drawn over the bank-head towards the Old Tunnel Mouth. The wood-chock on the down line, near the cross-gate at the tunnel-mouth, must always be put across the rail immediately after the last luggage-train in the evening is gone down; also, if the brakesmen should on any account be obliged all to leave the tunnel-mouth, the chock must be put across the rails, and a man left in charge.

Instances of Fines and Dismissal, for the Information of the Enginemen.

H. H., engineman of the Milo engine, for running carelessly against a train on Whiston incline-plane, and thereby doing considerable damage; to be suspended three days and fined ten shillings.

Railway Office, 1st March, 1837.

H. H., engineman, W. L., fireman, of the Eclipse engine, with luggage-train. This train followed the six o'clock blue coach-train from Manchester, on Saturday evening, and near Bury Lane ran violently against a coach-train, by which several passengers were seriously hurt, and two first-class coaches much damaged; for this act of gross carelessness, the Directors order that H. H. and W. L. be discharged.

6th Feb. 1837.

J. H., engineman of the Cyclops, bank-engine, for propelling a train of goods on the level-way (on Friday morning, the 16th of June), contrary to the orders of the Directors: discharged from the service of the Company.—By order of the Directors.

Railway Office, 19th June, 1837.

N.B.—Every overlooker, engineman, guard, policeman, and gateman employed in the Liverpool and Manchester Railway, shall keep a copy of these rules constantly on his person, under a penalty of a fine of five shillings.—By order of the Directors.

March 1839.

LONDON AND BIRMINGHAM RAILWAY.

ROBERT STEPHENSON is the name of the distinguished engineer under whose direction the vast and difficult works of the London and Birmingham Railway have been so successfully brought to completion. This grand national undertaking is now in full operation, and the average receipts per week amount to no less a sum than sixteen thousand pounds!

A new impulse was given to the railway system so soon as the important advantages developed by the great Liverpool experiment were made known to the enterprising capitalists of the kingdom. Hitherto, a line of little more than thirty miles in length was the only one on which the new system of locomotion had been fairly tried; no sooner, however, was the experiment found to be successful, than the grand trunk-line between the two largest sea-ports in the kingdom was set on foot. The capital was speedily subscribed; the Acts of Parliament were obtained, although, in the case of the London and Birmingham Railway, not without considerable opposition, and the loss of one year; and now, after only six years, London and Lancaster are united by railway on the one side of the island, and London and Darlington on the other.

The important considerations of *safety*, *expedition*, and *economy*, have indeed been very sufficiently proved, as regards the London and Birmingham Railway, both to the satisfaction of the public and of the British government. The daily improvements making in the locomotive engine may fairly lead us to expect even a greater average speed than is at present attained; but we must also anticipate a considerable change for the better in regard to the regularity of trains in their arrival at intermediate stopping-places. It is by no means an uncommon case, even on this admirably-managed line, to be detained at an intermediate station for several minutes, by reason of the driver being unable to regulate the speed of his engine, and so to arrive at the station before the appointed time.

ACTS OF PARLIAMENT, SHARES, &c.—The first Act of Parliament for the construction of this work received the royal assent on the 6th May, 1833,

by which the Company was authorised to raise a capital in joint stock of 2,500,000*l.*, and by loan 835,000*l.* On the 3d July, 1835, a second Act was obtained for the purpose of extending the railway from Camden Town to Euston Grove, by which an additional loan of 165,000*l.* was allowed to be raised. On the 30th June, 1837, a third Act was passed, empowering the Company to raise by loan 1,000,000*l.* additional; and again, in 1839, the Company made application to Parliament, and obtained power to raise a further sum of 1,000,000*l.*; thus making a total of 5,500,000*l.*

The number of 100*l.* shares is 25,000, which produce a sum of 2,500,000*l.*, of which 90*l.* had been called up to the 30th June, 1840; 25,000 quarter-shares, amounting to 625,000*l.*, of which 5*l.*, or one-fifth, had been called on each share up to the same date; 31,250 shares of 32*l.* each, amounting to 1,000,000*l.*, of which 24*l.* had been called on each share; thus making the total number of shares 81,250, on account of which 3,125,000*l.* had been paid up, leaving 1,000,000*l.* yet to be called for.*

All the loans and mortgages have been effected at an average interest of 4½ per cent, and have a priority of claim as regards payment from the profits of the concern before dividends to the proprietors.

OPENINGS OF THE LINE.—This railway was first opened to the public as far as Boxmoor, on the 20th July, 1837. The second portion opened extended to Tring; this took place on the 16th October of the same year.

* Amount received for calls	£ 3,125,000
Debentures:—	
Mortgage of tolls and calls, 3 Wm. IV. c. 36 . . .	£ 835,000
" " " 5 and 6 Wm. IV. c. 56 . .	165,000
" " " 1 Victoria, c. 64 . . .	375,000
	<hr/>
	1,375,000
Security on calls not made on the 100 <i>l.</i> and 25 <i>l.</i> shares	750,000
	<hr/>
	2,125,000
	<hr/>
	£ 5,250,000
To balance, being 8 <i>l.</i> per share on 32 <i>l.</i> shares not called for . . .	250,000
	<hr/>
	<u>£ 5,500,000</u>

On April 9th, 1838, a further opening was effected as far as Denbigh Hall, and on the same day that portion of the line lying between Birmingham and Rugby was also opened, the intermediate length being worked by common-road coaches; and the line was opened throughout on the 17th September, 1838. The Aylesbury branch was opened on June 10th, 1839.

GENERAL COURSE OF THE LINE.—Leaving the Euston station, London, the line crosses the Hampstead Road to the south-west of Mornington Crescent, passes under Park Street, and continues to the Camden depôt; from whence it is traced in a curving course between the Hampstead Road and Primrose Hill, crossing the New Finchley Road, and continuing thence to Kilburn, Kensall Green, and Harlsden Green, and passing to the right of Harrow and Pinner, from whence it is produced towards Watford, which is on the left. It thence approaches near to the following places, viz. Two Waters, Berkhamstead, Tring, Leighton, Fenny Stratford, Wolverton, Stony Stratford, Blisworth, Weedon, Kilsby, Rugby, Church Lawton, Brandon, Wolstone, Coventry, Berkswell, Hampton-in-Arden, and Yardley; from whence it is continued to its termination in Curzon Street, Birmingham.

The whole line is furnished with a double way throughout, with numerous additional lines, sidings, and traverses, at the various stations; and between Euston station and the Camden depôt there are four lines of way.

The worst curve on the main line is at the crossing of Chalk Farm Lane, which is of about 600 yards radius, extending from the tunnel to the divergence of the line running off to the goods-depôt.

GRADIENTS.—Having a portion of the line, between the Euston station and the Camden depôt, worked by fixed engines on account of the inclinations of 1 in 66 and 1 in 75, this railway, according to our mode of classification, comes under the third class; although, in point of fact, with these exceptions, the whole line has first-class gradients. In laying out this railway, Mr. Robert Stephenson had great difficulties to contend with in almost every portion; several sections were made before that which has been adopted was fixed upon. Indeed the whole country was explored for many miles on either side of the line; and from the nature of the works of the London and Birmingham Railway, it may readily be conceived how difficult a task he had

to perform, in fixing upon the precise course to be taken. It must ever be remembered that Mr. Stephenson's grand object was to make this railway as mechanically perfect as possible ; or, in other words, to reduce the gradients to the minimum consistent with the natural difficulties to be encountered throughout.

In looking at the section of this railway, four summits present themselves, viz. that of Tring, which is 332 feet 4 inches above the level of the Euston station ; the Blisworth summit, which is 170 feet 10 inches ; the Kilsby summit, 308 feet ; and that of Berkswell, 290 feet above the same level.

Commencing at the London terminus, the lengths and inclinations of the fixed-engine planes are as follows :—

Total Distance.		Length of Plane.		Ratio of Inclination.	Locations.
Mile.	Chains.		Chains.		
	12	12		descending at the rate of 1 in 156	
	25	13		level	Hampstead Road.
	42	17		ascending „ 1 in 66	
	60	18		ascending „ 1 in 110	Park Street.
	68	8		ascending „ 1 in 132	
1 04	16			ascending „ 1 in 75	Camden depôt.

From the Camden depôt to the Tring summit, a distance of 29 miles 77 chains, the line is divided into nineteen planes, of which eight are ascending, and vary in inclination from 1 in 330 to 1 in 1056 ; the descending planes are five in number, and have inclinations of from 1 in 330 to 1 in 1650 ; and the remainder is level. The line from thence makes a dip to Wolverton, a distance of 21 miles 39 chains, with inclinations varying from 1 in 330 to 1 in 1662. In this length there are two ascending planes, amounting in length to 3 miles 39 chains, and rising at the rates of 1 in 1320 and 1 in 1100 respectively. From Wolverton the line ascends to the second, or Blisworth summit, a distance of 8 miles 13 chains. In this length there are four planes ; the first being level, the second rising at the rate of 1 in 330, the next at 1 in 412, and the last at 1 in 335. The second dip is to Weedon, a distance of 8 miles 69 chains, which is divided into seven planes ; five descending with inclinations of from 1 in 326 to 1 in 2640, one ascending for 1 mile 14 chains at the rate of 1 in 960, and one level for 47 chains. From

Weedon, the Blisworth summit is reached in 6 miles 76 chains, by five ascending planes, with inclinations of from 1 in 340 to 1 in 880.

The dip from the Blisworth summit to Brandon is accomplished by three descending planes, amounting in length to 12 miles 47 chains, with the respective inclinations of 1 in 849, 1 in 364, and 1 in 660. The fourth, or Berkswell summit, is 9 miles 56 chains from the bottom of the last dip at Brandon; this reach is made up of two level planes, amounting in length to 2 miles 38 chains, and one inclined plane, rising at the rate of 1 in 330, for 7 miles 18 chains. From the Berkswell summit to Birmingham, the distance is 13 miles 59 chains; the first plane of which falls at the rate of 1 in 330 for 3 miles 49 chains; the two planes next in order ascend, the first at the rate of 1 in 1370, and the last at 1 in 660; and, finally, the Birmingham terminal plane is level; the whole distance between the termini being 112·25 miles.

The prevailing gradient is that of sixteen feet, or 1 in 330; the whole length graduated with this inclination is 29 miles 57 chains, being more than a fourth of the total distance, of which $19\frac{1}{4}$ miles are ascending in the direction from London. The planes ascending in the direction towards Birmingham amount altogether to 55 miles 33 chains; and the descending planes in the same direction to 43 miles 24 chains.

GAUGE OF WAY, &c.—The gauge of way was fixed in the case of this railway, as of all other English lines until the passing of the Great Western and Eastern Counties Acts, at 4 feet $8\frac{1}{2}$ inches; and it is only to be regretted that this subject had not been more attended to before the gauge became a fixed measure. A clause for the securing of the national gauge was inserted in each Act of Parliament, until Mr. Brunel and Mr. Braithwaite, who had considered it essential to increase the width, although it is well known to a very different extent, each managed to secure his own peculiar gauge. The results of these alterations will be seen in future years; at present we have not had sufficient experience of each of the new systems to determine which is actually the best.

The gauge, as above stated, of the Birmingham Railway is 4 feet $8\frac{1}{2}$ inches, the intermediate space 6 feet 5 inches, and each side space 7 feet 1 inch, making the top width of embankments, or between side-drains of

cuttings, 30 feet. At the cutting close to the Watford station, the side space next the platform is 2 feet 2½ inches; and that on the side next the ditch 6 feet.

RAILS, CHAIRS, &c.—The rails originally introduced on this line were of the fish-bellied form, weighing about 50 lbs. to the yard, a few of which still remain at Kensall Green and Watford; but Professor Barlow's report to the Directors of this Company completely set this question at rest, and now fish-bellied rails are almost discarded. The larger proportion of this way is laid with 65 lbs. and 75 lbs. parallel rails, in 15 feet lengths (see plate of Rails, fig. 38); the bearings for the parallel rails being 3 feet 9 inches and 4 feet respectively. The rails are fixed in chairs of ordinary form, and secured thereto by compressed wooden keys, according to the now generally adopted plan. There are three kinds of keys, viz. those of 4 inches in length, which cost 12*l.* per 1000, and others of 5½ and 6 inches long respectively, which cost 16*l.* per 1000. The intermediate chairs weigh each 26½ lbs., and the joint chairs 31 lbs.

The rails and chairs were supplied chiefly from the works of Bailey, Brothers; the Rhymney Company; the Birtley Iron Company; Bradley and Co., of Stourbridge; and Hawks, Stanley, and Co., of Newcastle; the cost of rails being about 9*l.* 10*s.*, and of chairs 9*l.* 7*s.* per ton, on an average. The rails and chairs are stated to have cost altogether 460,000*l.*

On embankments transverse sleepers of Scotch fir, larch, and oak, are used as the foundation for the rails; and in cuttings, stone blocks; but on many parts of the line sleepers have been substituted to a great extent. The sleepers are 7 feet in length, having a scantling of 9 inches by 5 inches; the cost is about 7*s.* each, exclusive of kyanizing, which adds 9*d.* additional to each sleeper. The blocks are of Cornish granite and Whitby limestone, and are chiefly placed diagonally; a plan now being much followed on the northern railways recently finished, or in the course of execution. The joint-blocks contain each 5, and the intermediate-blocks 4 cubic feet.

The ballast is chiefly of gravel, 2 feet in thickness; in some parts, however, the gravel is in a thinner layer, and is superposed with loamy sand. This plan is adopted very much on the Belgian railways, and appears to answer the purpose extremely well. Flint and chalk, and gravel and chalk, are also used in some parts of the line.

The drainage throughout this railway is of the best description; no expense has been spared to make it in every respect complete. The open side-drains are about 21 inches wide at top, 12 inches wide at bottom, and 24 inches deep. Cross under-ground circular and perforated tile-drains are used to a great extent, at intervals of 10 yards each; and in the large and deep chalk cutting at Tring the side-drains are of brick, of large dimensions, running the whole length of cutting under ground, with cess-pools, or eyes, at convenient distances to take off the surface-water. Semicircular half-brick open-drains are used for the sides of some of the cuttings; and the under-ground drains, in some parts, are of semicircular form, perforated, and based on 12-inch square paving-tiles.

The fencing is chiefly of posts and rails, with quick planted on one side. The number of rails to the fencing varies according to the nature of the cultivation of the contiguous lands, or agreement with the respective proprietors. There are very few fences with less than four rails; some have six rails, and others three rails and two intermediate wires. This seems to be an economical and useful description, and is much used on the Grand Junction Railway. Another description of the fencing of this line consists of three rails and space and pale for half the height from the ground. This plan has been adopted in parts of the North Midland Railway.

From the Camden depôt to the crossing of the Edgeware Road, the fencing consists of substantial brick walls, with stone copings, the whole height being about 5 feet. Although very expensive, such protection is absolutely necessary in a locality so near to the metropolis.

The distances are painted conspicuously on the large heads of wooden standards placed on one side of the way, and at intervals of a quarter of a mile each.

EARTHWORKS.—There is scarcely a portion of this line, from one end to the other, which is not either carried by embankment above the general surface of the country, or sunk below it by means of excavation. It has, indeed, in point of execution, been one of the most difficult works of the kind in the kingdom. London clay, disrupted chalk, and running sands, have sadly impeded the progress of the works; yet such is the perseverance of man, when he sets about a work in earnest, that all the formidable difficulties which sprang up in quick succession, and for awhile seemed to arrest

the progress of the works, have been very creditably surmounted, and now the public is in full enjoyment of the benefits of this vast undertaking.

By the original section the excavations amounted to 12,081,116, and the embankments to 10,698,315 cubic yards; but we have been unable to obtain such particulars as we could have desired of the earthworks, and other important features in the engineering department of this splendid undertaking.

VIADUCTS AND BRIDGES.—Among the principal works in the bridge-building department, are the Lawley Street viaduct, at Birmingham; the viaducts over the rivers Sowe, Colne, and Brent; and the bridge over the Regent's Canal, at Camden Town.

The Colne viaduct is built of brick with stone imposts, dressings, and copings, and consists of five semicircular arches, each of 30-feet span, and two land-arches on each side, each of 10 feet; the clear height of the river-arch is 35 feet, the clear width between the parapets is 28 feet, and its total length 312 feet.

The viaduct over the valley of the Brent is also constructed of brick and stone; it consists of one river-arch, 3 feet 9 inches in thickness, and of 60-feet span, and six semicircular land-arches, each of 15 feet 8 inches span. The springing line of the river-arch is about 5 feet above the ordinary summer water; the clear width between parapets is 28 feet, the wing-walls are built with a considerable batter, and the piers are built in hollow panels.

There are at the rate of about $2\frac{1}{2}$ bridges per mile, taken throughout.

Across some of the cuttings three-arch bridges are introduced, the centre arch in such cases being 22 feet in span. Single segment arches are thrown across the sandstone cutting at Coventry, the abutments being formed of the natural rock.

Some of the bridges over the railway, which are of semi-elliptical form, are of 30-feet span, having a versed sine of 8 feet, the arch being $22\frac{1}{2}$ inches in thickness. In the London division the bridges are numbered throughout.

The iron-tie bridge over the Regent's Canal at Camden Town, which is one of the most ingenious structures on the whole line, was designed by Mr. Fox, one of the resident engineers, for the purpose of conveying the railway at an elevation of only 13 feet above the surface of the water,

and with a span of not less than 50 feet. The structure consists of three main cast-iron open ribs, each composed of two large castings, extending the whole width of opening, and having a bearing at each end of 4 feet. These minor ribs are connected together by transverse iron bracing. The pedestals, on which the ribs take their bearings, are 10 feet long, 6 feet wide, and 30 feet high, and are built of brick and stone, founded on a bed of concrete 2 feet in thickness. Eight cross girders run from either side main rib to the centre main rib, from which they are severally suspended at each end by vertical rods and keys. The girders are of fish-bellied form, and are each 28 feet in length, and 2 feet deep in the middle. The thrust of each arch is sustained by wrought iron tie-bolts running from end to end of the ribs. To the front of the ribs is bolted open ornamental work, which gives to the whole a pleasing appearance. The extreme width of this bridge is 60 feet. The rails over the bridge are set in chairs, and bolted thereto. The chairs are fixed on oak slabs running longitudinally, and resting on the tops of the girders. The side and intermediate spaces, and also the space between each pair of rails, are covered with iron gratings, furnished with flanches underneath to strengthen them.

TUNNELS.—The principal tunnels on this line are those of Primrose Hill, which is 1120 yards in length; Kensal Green (curved), 320 yards; Watford, 1830 yards; Leighton (curved), 272 yards; Weedon, 418 yards; Kilsby, 2398 yards; and Berkswell, 300.

The Kilsby tunnel, which is by far the chief work of the kind on this railway, is stated to have cost about 125·104*l.* per yard lineal.

The Kensal Green tunnel is built in a slightly curving line; it is of brickwork throughout, and is of 22-feet span. For the execution of this tunnel a trench was excavated from end to end, the sides being shored up during the time the works were in progress.

The tunnels are generally of a width of 24 feet, and of a clear height above the rails of 23 feet.

The Primrose Hill tunnel is of three bricks in thickness, and built in cement, with an invert of two bricks. Stone springers are used throughout at the meetings of the side-walls and invert. The vertical shafts used in forming the different tunnels are generally of 9 feet in diameter.

The fronts of the Primrose Hill, Kilsby, and other tunnels on this line, are generally of stone, and some of them of far too elaborate design.

STATIONS AND DEPÔTS.—Besides the principal stations of London and Birmingham, there are eight first-class intermediate stations, viz. Watford, Tring, Leighton, Wolverton, Blisworth, Weedon, Rugby, and Coventry; and eight second-class stations, viz. Harrow, Boxmoor, Berkhamstead, Bletchley, Roade, Crick, Brandon, and Hampton. There is besides a stopping-place at the Camden depôt, which is the point of departure and arrival of the locomotive engines; and another at the Aylesbury junction.

The stations, taken in order, are as follows, with the respective distance of each from the London terminus:—Harrow, $11\frac{1}{2}$ miles; Watford, $17\frac{1}{2}$; Boxmoor, $24\frac{1}{2}$; Berkhamstead, 28; Tring, $31\frac{1}{2}$; Leighton, 41; Bletchley, $46\frac{1}{2}$; Wolverton, $52\frac{1}{2}$; Roade, 60; Blisworth, $62\frac{1}{2}$; Weedon, $69\frac{1}{2}$; Crick, $75\frac{1}{2}$; Rugby, $83\frac{1}{2}$; Brandon, $89\frac{1}{2}$; Coventry, 94; Hampton, 103; and Birmingham, $112\frac{1}{2}$ miles.

The goods-depôts, and also the principal locomotive-stations, are at Wolverton, Camden Town, and Birmingham.

The revised estimate for the stations and depôts was about 70,000*l.*; the actual cost has been upwards of 360,000*l.**

The first-class stations of Tring, Rugby, and Coventry, are described fully below. A second-class station on this railway consists usually of a building in the cottage style, in which are the booking-office and waiting-room, a front court enclosed with space and pale-fencing, and the usual conveniences, with separate gates for the arrival and departure of passengers.

EUSTON STATION.—Although we are far from advocating extravagant expenditure in any of the buildings connected with railways, we are inclined to think that the grand Doric entrance to the Euston station, from the design of Mr. Hardwick, which is, as it were, the key to all the railways north of London, is perfectly allowable. There are two lodges on either side of the Doric entrance, which are used as coach, mail, and parcels-offices. Besides

* The Euston station cost 81,532*l.*; the Camden depôt, 114,385*l.*; and that of Wolverton, 109,454*l.* The intermediate stations from London to Wolverton cost together 25,386*l.*

the grand entrance, there are two side gateways, each furnished with handsome iron ornamental gates; that on the right leading to and from the carriage-landing, and that on the left being for the departure of carriages which have set down passengers going by the trains. There are also two gateways for the admission and departure of hackney-coaches, cabriolets, &c. to and from the arrival-platform.

In departing from London, the entrance for carriages and foot-passengers is under the grand portico: the carriage-approach to the offices, which are on the right, is by means of a granite-paved roadway; at the north end of which, and beyond the offices, is an area of about 135 feet in length, and about 66 feet wide, on an average, which affords ample accommodation for carriages in waiting. The offices are contained in a brick structure 205 feet in length, and 20 feet in width, and consist of waiting-rooms, booking-offices for first, second, and third-class passengers; porter's room, ladies' apartments, &c., on the ground floor; and of the secretary's and clerks' offices, and the board-room, on the upper floor. Next the paved road there is a colonnade extending the whole length of this building, above which is an open passage for the use of the upper offices: the other side of the building presents a frontage to the departure-stage, which is of the same length, and about 16 feet in width. The arrival-stage is on the opposite side of the railway, is also 16 feet wide, and extends the whole length of the shed, which is supported on one side by the external wall of the offices, and on the other side, and along the middle line, by two rows of iron columns, altogether twenty-two in number.

There are four lines of way at this station, which terminate in as many turning-platforms contiguous to the carriage-wharf: the whole width of this shed is 80 feet, and the length 200 feet; the roof is constructed of iron rafters, struts, and ties, and presents a light and pleasing appearance.

At the north end of the shed are four corresponding turn-tables, from which the four lines of way pass with a quick curve towards the first bridge, which carries Wriothsley Street over the railway.

A cross line intersects the main lines at a distance of 240 feet from the north end of the passenger-shed, furnished with four turn-plates for the purpose of conducting the carriages to or from the carriage-house. The area occupied by this station is equal to about five acres.

LONDON FIXED-ENGINE PLANES.—From the Euston station to the Camden depôt there are four lines of way, which are carried as far as Park Street between retaining walls: the clear width occupied here is about 56 feet; the retaining walls are about 19 feet in height, and are built to a curved batter, with a radius of about 60 feet, the versed sine being about 4 feet 10 inches; the lowest part of the foundation is 7 feet from the level of the rails; the thickness of brickwork decreases from the footings upwards, being at the bottom 3 feet 11½ inches, and at the top 2 feet 7½ inches. The whole length of these walls extends to upwards of 2,200 yards.

In this length there are seven bridges and archways over the railway, each of which is in two spans. Some of these bridges are built of brick and faced with stone; and others have iron ribs resting on brick piers.

From Park Street to the Regent's Canal bridge at Camden Town the rails are near the general surface of the ground; and the railway is enclosed on either side with neat iron railing and pedestals of brick resting on dwarf walls.

As these planes are considerably curved in some portions, both vertical and sloping sheeves are used for the rope; they are fixed in cast-iron cases bedded in the ballasting.

CAMDEN DEPÔT.—The Camden depôt, which occupies an area of about twenty-seven acres, is bounded on the east by the Hampstead Road, on the north by Chalk Farm Lane, on the west by a new road formed from Park Street to Chalk Lane, and on the south by the Regent's Canal. It is altogether raised on an embankment of clay, the produce of the Primrose Hill tunnel and contiguous cuttings.

The goods-sheds and docks for common-road wagons, as also the general offices, are situate near the turnpike in the Hampstead Road, from which they are severally entered. At this depôt are also situate the coke-ovens, the locomotive-engine shed, the fixed engines to work the inclined planes from Euston station, and also the wagons' building and repairing-sheds. A double line of way diverges from the main passenger-line near the Chalk Farm Lane bridge, and runs in a direct course to the goods-department.

STATIONARY ENGINES AT THE CAMDEN DEPÔT.—The stationary engine-house at the Camden depôt, and on the north side of the Regent's Canal,

is altogether below the level of the railway. The engine-room, which occupies the central portion of this building, is 72 feet in length and 30 feet in width, at each end of which is situate a boiler-room 44 feet long and 24 feet wide. On the north side of each boiler-room is erected a circular chimney of beautiful symmetry and exquisite workmanship, which rests on a pedestal 12 feet 8 inches square, and 23 feet high above the footings; the footings project 3 feet 2 inches on each side, and are altogether 8 feet in height. The foundation consists of a bed of concrete 6 feet in depth and 26 feet square: the total height of each chimney is 132 feet 3 inches; the external diameter of the shaft at its base is 12 feet 8 inches; from the top of the pedestal, for a height of 15 feet, it takes a curved batter, at which height the diameter is reduced to 10 feet; from this level to the top it forms the frustrum of a cone, the top diameter being 5 feet 6 inches; the brickwork of the shaft decreases in thickness by regular steps from 2 feet 4 inches at bottom to 9 inches at top, which is finished with a handsome moulded cap. These elegant chimneys afford a fair sample of the approach to perfection which has in our own times been made in this, as in many other of the useful arts.

At the south end of each of the boiler-rooms is a small workshop 20 feet in length and 15 feet in width; and between these shops, and abutting on the south side of the engine-room, there are two coal-stores, each 15 feet in clear width, and extending for a length of 112 feet. Between the coal-stores are compartments, in which are placed parts of the rope-apparatus, including the tightening-sheeves and counterbalance-wells.

The engine-house is entered from the railway by a stone-staircase descending at once into the engine-room.

The fixed engines used for working the inclined planes between the Euston station and the Camden depôt are from the works of Messrs. Maudsley, Son, and Field, and are executed in their usual masterly style. Each engine is stated to be of 60-horse power; the boilers are of the description used for marine purposes, and are each 18 feet long, 7 feet wide, and 8 feet high. The engines and boilers are fixed in the rooms already described; the cylinders are 43 inches in diameter, and the stroke is 4 feet; the usual working pressure is $4\frac{1}{2}$ lbs. on the square inch.

The mode of drawing up the trains is by an endless rope, which passes over sheeves in the usual way, running down one line of way to the Euston station, and returning by the other to its meeting at the engine-house. This

rope when new measured 4,080 yards, or 2·318 miles in length, and 7 inches in circumference: its original cost is stated to have been 476*l.* 19*s.*, and its weight 11 tons 15 cwt., or 26,320 lbs. It was furnished from the works of Messrs. Huddart and Company of Limehouse. The motion from the engine is communicated to the driving-wheel by a horizontal shaft in the usual manner. The driving-wheel is 20 feet in diameter, and consists of eight segments, and as many arms; the rim is 12 inches in width, and has on its outer surface three grooves to receive the rope, which passes as many times round it. At the distance of 26 feet 6 inches from the central line of the driving-wheel are two other wheels, one of 12 feet in diameter, which is in the same line as the driving-wheel, and round which the rope passes once; and the other 20 feet in diameter, and 11 feet 2½ inches to the left of the smaller wheel. Round this latter wheel the rope passes over to the railway, and under to the horizontal tightening-sheave, which is 12 feet in diameter, and is fixed on a truck running on a railway as at the Edgehill station, Liverpool.* At a distance from the driving-wheel of 121 feet is a well 4 feet in diameter and 82 feet in depth, in which the counter-weight connected with the tightening-wheel is suspended.

For starting the engine, a signal is given to the engine-man by means of the pneumatic telegraph laid down from Euston station into the engine-house.

Besides the large engines above described, a six-horse engine is used for the purpose of exhausting the condenser, in order to be able to put the machinery in motion immediately upon the signal being given. The time usually occupied in drawing up the trains from Euston Square, a distance of rather more than a mile, is from three and a half to five minutes, according to the load.

The quantity of Welch coal used when there were eleven trains daily was stated to amount to about three tons per diem.

These engines commenced working regularly on the 14th October, 1837, since which time they have required very little outlay for repairs. Besides the engine-man, there are three stokers and cleaners attached to this department.

The cost of working these engines, and the machinery connected with

* See page 194.

the inclined planes, between Euston station and Camden depôt, amounted for six months ending 30th June, 1840, to 1,268*l.* 3*s.*

The locomotive engines' station at the Camden depôt is a rectangular building of brick, enclosing an open quadrilateral space, and is situate on the right side of the railway going from London, and near to the high chimneys belonging to the fixed engines. The entrance to this station is by branches from the main line, which pass under two archways in front of the structure; in each of these gateways is an engine turn-table, and a water-column on either side of the way, and above is fixed a large tank.

In the front part of this building is situate the stores' department; on one side of which, and next the right gateway, are placed a room for the engine-drivers and stokers, and the paint-room; and on the other side a furnace for igniting the coke for the locomotive engines and a coal-store. On the other side of each gateway is a small turnery, with two double hearths in each. The engine-sheds, which occupy each side and also the back part of the building, are open next to the quadrangle, and covered with light iron roofs; each side-shed will hold ten engines, or five engines and five tenders, in as many cross lines, which communicate with the branches by means of turntables, each of 12 feet diameter, placed at the several intersections.

COKE. — At the Camden depôt, and contiguous to the Regent's Canal, are situate the coke-ovens and coal-store, which were arranged by, and are under the immediate superintendence of, Mr. Prior, who has acquired considerable experience in this important department of railways.

The ovens are ranged in double row along the middle of the area occupied by this department, which is about 10 feet below the general level of the Camden depôt: they are eighteen in number, and of elliptical form, the respective diameters being 12 feet and 11 feet; their height is 4 feet 9 inches. Each oven is bound with three iron girdles, 5 inches wide and $\frac{3}{4}$ -inch thick. The flue runs quite round over the ovens, and terminates in the chimney, which is at the end nearest the Regent's Canal. On one side of the ovens is the coal-store, and on the other that for the coke. The communication from the depôt to the coke-ovens and office, which is one corner of the area, is by a flight of steps. The whole of the coke has to be raised to the level of the depôt, which is a decided objection. The ovens on the

South Western Railway are equally defective in point of situation; but on the Great Western Railway the ovens are on the same level as the railway.

The coals used for coking in the London and Birmingham coke-ovens are from Newcastle, and are known as Tanfield Moor and Windsor's Pontop, being mixed in equal proportions.

There are six cisterns of water conveniently situated for cooling the coke when laid on the brick cooling-floor, the water being supplied from the Regent's Canal. The time occupied in the operation of coking is forty-four hours, and in charging and drawing the ovens four hours.

Nine ovens are charged daily; each oven contains 68 cwt. of coal: the quantity of coal daily charged is, therefore, 30 tons 12 cwt., which produces 23 tons 8 cwt. of coke.

The number of men employed in this department, including nine stokers, is twenty, besides ten lads. The wages of the firemen are 30s.; of the stokers, 27s.; and of the lads, 15s. 6d. each per week respectively.

TRING (FIRST-CLASS) STATION.—The station at Tring is inconveniently placed in cutting, as was the original Coventry station. The offices are on an elevation equal to the depth of the cutting, and are approached from the railway by a flight of 18½ 7-inch steps for foot-passengers, and a sloped road for the private carriages to be embarked or disembarked at the carriage-dock. There is a separate passage from the railway for the departure of persons arriving by the trains, and also a separate staircase for the use of the porters.

The offices consist of a booking-office and waiting-room in one, with an entrance-lobby next the road, and exit-lobby towards the railway. The width of this building, which is constructed of brick, is 32 feet, and the depth 24 feet 5 inches. A paved yard extends in front of the offices for a length of 58 feet, being 33 feet in depth; the front next the railway is enclosed with iron railings. The urinals and water-closets are conveniently placed on the north side of the offices, and entered from the paved yard. There is also a porter's lodge, which is detached from the other offices.

The fixed-engine and boiler-house are about 33 feet in length and 18 feet 6 inches in width, and abut on the north side of the paved yard. The coal-shed, which is contiguous, is 23 feet in length and about 7 feet wide. The

engine has an 8-inch cylinder and 18-inch stroke; the usual working pressure is 31 lbs. on the square inch. There are two boilers, with return tubes. The water-tank is placed over the engine and boiler-house: the usual depth of water is 3 feet 6 inches. The quantity of water which this tank will hold is equal to the supply of eight or nine locomotive engines. The supply-pipes from the pumps are each of 6 inches diameter. From the boiler the waste-steam is admitted by a $2\frac{1}{2}$ -inch pipe into the water-tank, to raise the temperature of the water previously to its being let into the tanks of tenders.

The water used at this station being of excellent quality is taken in by most of the locomotive engines: it is obtained from a depth of 80 feet, the well is of 7 feet diameter.

Besides the booking-clerk, there are at this station one inspector, three policemen, four porters, and one stationary engine-man.

The carriage-dock is approached by a siding from the main line, furnished with a 12-foot turn-table opposite the entrance to the dock. This dock is 14 feet in length, 9 feet $5\frac{1}{2}$ inches in width, and 3 feet deep.

Some of the ballast-engines are housed in a shed at this station.

One horse-box and carriage-truck are kept at this, as at all the first-class stations.

LOCOMOTIVE ENGINE-DEPÔT, GOODS-DEPÔT, AND PASSENGER-STATION AT WOLVERTON.—The buildings lately erected at Wolverton, as the principal station for the locomotive engines, form, perhaps, one of the most complete establishments of the kind in the world. The site of this establishment is on the left side of the railway, at a distance of about $52\frac{1}{2}$ miles from the London terminus, and $59\frac{1}{2}$ miles from that of Birmingham, having a frontage on the Grand Junction Canal. The buildings, which are of plain but neat design, and constructed chiefly of brick, surround a quadrangular space 127 feet wide by 216 feet deep, the entrance to which is under an archway in the centre of the principal front. The whole length of the buildings is 221 feet, the depth 314 feet 6 inches, and the height 23 feet; the main walls are $2\frac{1}{2}$ bricks in thickness. Besides the central gateway, which is 12 feet 6 inches in height above the rails, there are two side-entrances: the one to the large erecting-shop, the other to the repairing-shop.

The erecting-shop is on the right of the central gateway, and occupies

one half of the front part of this building. It has a line of way down the middle, communicating with a turn-table in the principal entrance, and also with the small erecting-shop, which is on the left of this entrance. Powerful cranes are fixed in the erecting-shops for raising and lowering the engines when required.

Contiguous to the small erecting-shop, and occupying the principal portion of the left wing, is the repairing-shop, which is entered by the left gateway. One line runs down the middle of this shop, with nine turn-tables, and as many lines of way at right angles to the central line. This shop is 131 feet 6 inches long and 90 feet wide, both in the clear, and will hold eighteen engines and tenders, or thirty-six engines. It is lighted by twenty-four windows, reaching nearly to the roof.

In the same wing, and next to the repairing-shop, is the tender-wrights' shop, having the central line of way of the repairing-shop running down its whole length, with a turn-table and cross line, which runs quite across the quadrangle, and intersects a line from the principal entry to the boiler-shop in the rear of the quadrangle.

The remainder of the left wing is occupied by a room for stores on the ground-floor, with a brass-foundry and store-room over; and the iron-foundry, which extends to the back line of the buildings.

The right wing contains the upper and lower turneries, each 99 feet long and 40 feet wide; the upper floor being supported in mid-line by nine iron columns. There are fourteen lathes in the lower, and eight in the upper turnery. The fixed pumping-engine house is also in the right wing, occupying the central portion thereof, and measuring 26 feet 3 inches by 19 feet 6 inches. There are two engines, each having a 14-inch cylinder and 4-feet stroke, and worked with from 35 lbs. to 40 lbs. pressure; the fly-wheels making twenty-four revolutions per minute. The boilers are placed in a sunk area in front of the engines, and separated therefrom by a 9-inch wall. The water is pumped from a well in the centre of the engine-house; this well is of elliptical form, the transverse and conjugate diameters of which are respectively 11 feet 6 inches and 8 feet 2 inches. The brickwork is 9 inches thick, and the whole depth of well 93 feet. At the bottom of the well are two tunnels, running north and south, each extending 33 feet from the well. These tunnels are 8 feet wide, 8 feet 6 inches in extreme height, and 6 feet

to springing of segmental arch; the brickwork is $13\frac{1}{4}$ inches in thickness. The two pumps are each of 7 inches diameter. There are two tanks to receive the water from the well: the one above the engine-house having a capacity equal to 2590 cubic feet, or 15,540 gallons; and the other 3850 cubic feet, or 23,100 gallons. This latter tank is over the gateway.

Besides pumping water for the establishment, and giving motion to the lathes and other machinery, these engines have another duty to perform, which is that of working the blowing-machine. The blowing-cylinders are fixed on a floor above, and immediately over the engine-cylinders, are 3 feet in diameter, and are worked by the same piston-rods, having a 4-feet stroke. The air is admitted at the top of the blowing-cylinder by a pipe communicating with a vertical cylinder, 10 inches in diameter, which is carried out above the roof. The 9-inch blast-pipe passes from the top of the cylinder, on the opposite side to that in which the air is admitted, and runs down to the level of the smithy, to blow the numerous fires which range along the sides and ends.

The smithy occupies the north-west angle of the building, running partly down the right wing, to the extent of 137 feet 3 inches, and joining the engine-house, and partly along the back portion of the building, to the extent of 76 feet. It contains eighteen single, and three double hearths.

The remaining space of the back portion of the buildings is occupied by a joiners'-shop, with store-room and pattern-shop above, the hooping-furnaces, and a boiler-shop. In the boiler-shop there are two hearths; and, communicating with the machinery worked by the engines above described, are two drills and a punch.

The lodge, superintendent's office, and drawing-office, are in a building within the quadrangle, and close to the principal entrance.

The various departments of this establishment are warmed by steam, issuing through cast-iron pipes laid in channels, paved over, and furnished with proper ventilators.

On each side of this extensive structure there is a street running down to a wider street at back, which is 40 feet in width, including the footpaths. In the left street are the gas-works, and eight cottages of two stories for the workmen. Between the street on the right and the canal, other streets run down at right angles. In the principal street, which is at the back of the

locomotives' building, there are six houses of three stories, for clerks and foremen; twenty-two of two stories; and eight with shops on the ground-floor. From the main street there is a communication with the high road, which passes over the railway to the south of this station.

In front of the locomotives' building there are four lines of way; the main double way being in the middle, with an intermediate space of 6 feet 5 inches, the whole width of way being about 60 feet. On the side-line next the building are two engine-races, or pits, 3 feet 9½ inches wide, and 2 feet 4 inches deep from level of rails. A grating is fixed in the bottom of each race, to let off the water from the engines, when required, into a proper drain below. On the cross lines, which are in communication with the locomotives' establishment, are six turn-tables; two of which are in front of the carriage-landing, which is on the east side of the railway. In this carriage-wharf or landing there are two docks or recesses, each 9 feet 2 inches wide, 5 feet deep, and 3 feet 8½ inches high, with proper indents in the coping to receive the buffers and chains. To support this wharf four needle piles of oak are driven at a distance of about 10 feet 6 inches from the back of the wall, and between these piles and the elm planks, which are close to the wall, struts are introduced 10 feet in length. The whole width of this landing is 28 feet 6 inches, and it is run out with a proper slope leading from this station to the main road.

Fronting the canal, and on the east side of the railway, is the goods-warehouse, which is furnished with a double way, forming a communication with the main line. There are two lines of way running down the length of the warehouse between two stages or platforms, 15 feet wide and 4 feet high. On these stages are cranes for raising or lowering goods from or to the canal-barges or railway-wagons. Beneath the front stage is a coal-store, with six loop-holes next the canal. This building is lighted by four skylights in the roof, which is slated, and projects over part of the canal to protect the barges in bad weather.

The temporary passenger-station* is on the north side of the canal. Here the trains are allowed to stop ten minutes, provided they arrive in

* A convenient passenger-station is now building on the south side of the bridge over the railway at this place.

proper time, for the purpose of allowing passengers time to take refreshment.

Every engine with a train from London or from Birmingham is changed at the Wolverton station, which answers the double purpose of having it examined, and of easing the driver and stoker. We consider even fifty miles too great a distance to run an engine without examination; and have seen on other lines the ill consequences arising from the want of this necessary precaution. We should prefer about thirty miles' stages, when it can be managed.

RUGBY STATION.—The station at Rugby is situated on the west side of the railway, which at this place is on embankment. The station-house is set back from the railway about 30 feet, with a fore-court intervening about 34 feet in width. The building is 26 feet in front, and 31 feet 6 inches in depth. On the upper floor, which is on a level with the fore-court, is a spacious waiting-room, the descent from which to the booking-office below is by a flight of twenty steps. The police-inspectors' house is contiguous to the offices; and the conveniences are placed in the cellars underneath the fore-court.

The passengers leaving by a train pass through the booking-office and up the stairs into the waiting-room, and from thence across the fore-court to the platform; while those arriving leave the station by a flight of nineteen wooden steps, 6 feet in width, and on the right side of the fore-court.

The station-platform is of wood, 8 feet 10 inches wide; and between the two ways is a second platform of wood, 2 feet 9 inches wide, and 7 inches high above the rails. The whole width of way from the platform to the top of the slope on the opposite side is 26 feet 5 inches.

The stationary engine-house is on the opposite side of the way; and besides the engine and boiler-rooms, there are under the same roof the porter's lodge, oil-room, &c.

The pumping-engine has a 6-inch cylinder and 2-feet stroke; the usual working pressure is about 34 lbs. The water is derived from the river Avon, and let into a large tank built for the purpose.

At a distance from the station of about a quarter of a mile is a loco-

tive engine-house which will hold three engines and tenders.* There is also a carriage-shed at this station.

COVENTRY STATION.—The new Coventry station, which is one of the principal intermediate stopping-places, is situate on the right side of the way going from London, at a distance of about one hundred yards from the bridge which carries the Warwick turnpike-road over the railway. The original station was very inconveniently located, being at a considerable elevation above the railway, causing thereby much additional labour in carrying the passengers' luggage up and down a long flight of steps, besides the annoyance in bad weather to passengers, who had to pass from the booking-office to the railway without any protection from the elements.

The new station is, in all respects, free from such annoyance, and appears to be altogether well arranged. The level of the passenger-platforms is about 2 feet above the rails, whereby stepping up to the carriages is altogether avoided.

There are two sheds, each 226 feet 6 inches in length and 19 feet 6 inches in clear width; that on the left from London being for the *down* trains, and that on the right for the *up* trains. Through each shed a single way is laid from the main double way, which passes between the sheds. This arrangement admits of free passage on the main way during the stoppage of the trains at this station. Abutting on the inner side of each shed is a range of buildings, 92 feet 6 inches in length and 22 feet 8 inches in depth, containing a parcels-office, booking-office, general waiting-room, and ladies' waiting-room, with convenient water-closets and urinals. In front of this building is a paved platform 10 feet wide and 2 feet above the rails. The glass-doors, nine in number, in front of the station-buildings, remind us of some of the Belgian railway stations; and the same plan has been adopted in the Edmonton station of the Northern and Eastern Railway. In the rear of each shed is a covered way for common road-carriages, with a platform 6 feet wide next to the building. Apart from the buildings are two water-columns,

* The persons employed at this station are, one ticket-collector, one inspector, four police, five porters, one stationary engine-man, three engine-drivers, two firemen, two smiths, one stoker, three fitters, two cleaners, two coke-men, and two carpenters.

with engine-races 20 feet 6 inches in length, as also carriage-docks, with turning platforms conveniently arranged.

The whole station is enclosed with stone walls, and is approached from Coventry by gates at about seventy yards from the station-building.

The establishment, in August 1839, at the Coventry station consisted of the superintendent and two clerks, two ticket-collectors, one inspector, one policeman, ten porters, two switchmen, one gas-man, and one pumping-engine man.

There are usually kept at this station two first-class and two second-class carriages. There is a 6-horse pumping-engine on the west side. In the building containing this engine are also rooms for the police and porters. The well is about 30 feet deep, and 4 feet in diameter; and the water-tank is 20 feet 9 inches long, 14 feet 9 inches wide, and 4 feet deep.

There is also a locomotive engine-house to hold one engine and tender, with folding-gates at the entrance; within there are a smith's forge, anvil, and bench. On the siding at the entrance is a 12-feet turn-table. The urinals are enclosed with close boarding, and covered over with a shallow rain-water tank 8 inches in depth, a pipe from which conducts the water to the trough for the purpose of cleansing it. In front of this enclosure the name of the station is painted in conspicuous letters. The rates and tolls are painted on a large board at this station.*

BIRMINGHAM STATION.—The Birmingham station is situated in Curzon Street, contiguous to that of the Grand Junction Railway. The whole extent

* *Rates and Tolls.*

Dung, compost, manure, &c., 1*d.* per ton per mile.

Coals, coke, culm, &c., 1½*d.*

Sugar, grain, corn, timber, metals (except iron), nails, anvils, and chains, 2*d.*

Cotton, and other wools, drugs, hides, merchandise, &c., 3*d.*

Every person in or upon any carriage, 2*d.*

Horse, mule, ass, or other beast of draught or burthen, conveyed in or upon any carriage, 1½*d.*

Every calf, pig, sheep, lamb, or other small animal, in or upon any carriage, ¼*d.*

Any carriage other than a railway-carriage conveyed on a truck or platform, 4*d.* per ton per mile.

of this station is from New Canal Street to the Birmingham Canal, a length of about 860 feet : it is of very irregular form, varying in width from about 183 feet next New Canal Street to about 290 feet next the Canal. A stranger arriving at the station for the first time from Birmingham, to leave by the railway, would naturally take the Victoria hotel in Canal Street for the railway offices ; but this would have required the passenger-shed to have been quite different in point of location, and also of arrangement. As it is, the passenger-shed and offices are at some distance from the hotel, and placed at right angles thereto, ranging down the middle of the station. The roof of the passenger-shed, which is of neat and light appearance, and well constructed, is in two spans, each of 58 feet, supported on two lines of cast-iron columns, each twelve in number, and on the front wall of the offices. The whole length of the shed and offices is 233 feet. The arrival and departure-platforms are each 20 feet in width, and on a level with the floors of the carriages. The lines of way under the roof are six in number, the intermediate spaces being each 8 feet. At either end, and without the shed, are six 12-foot turn-tables ; towards the carriage-entrance from Canal Street there is an engine-dock 30 feet in length and 8 feet wide, and at the end of the down line. This affords room for a very long train to be altogether under cover at the same time, and also allows the turn-tables to be immediately used on the arrival of a train, which could not otherwise be done.

The booking-offices, waiting-rooms, and parcels-office, are arranged in the building already alluded to, which is 22 feet wide : in the rear, and extending the whole length of this building, is a covered platform 8 feet wide, the front of the roof resting on eighteen light iron columns. The court-yard, which is between the offices and Curzon Street, affords ample space for road-carriages arriving from Birmingham. The entrance to this yard is in New Canal Street ; there is also a foot-entrance from Curzon Street.

Opposite to the departure or up platform, and on one side of the hotel in New Canal Street, is a gateway for carriages intended to be conveyed by the railway, the carriage-wharf being at the end, but without the shed. On the other side of the hotel is a gateway, corresponding in design, for the departure of omnibuses and carriages in conjunction with the down-trains. At the end of the court-yard, and opposite to the carriage-entrance, but detached from

the booking-offices, is a building appropriated to the police and porters, the length of which is 55 feet.

Leaving the passenger-shed, the six lines of way are produced in straight lines for a distance of about 80 feet to a third tier of turn-tables, but only five in number. From these tables the lines diverge in different directions: one is produced to the Grand Junction shed on the left; three run into the locomotive engine-shed, which is placed close to the Birmingham Canal; and others into the main lines of way, passing over the wide bridge which carries both the Birmingham and Grand Junction Railways over the Canal.

BIRMINGHAM LOCOMOTIVES' STATION. — We shall next describe the Birmingham locomotives' establishment, as being an appendage to this station.

The building erected for the locomotive engines at the Birmingham station is of multilateral form, the diameter being 124 feet, and its centre being 418 feet from the last tier of turn-tables without the passenger-shed, and 88 feet from the Canal. Towards the passenger-station is a building projecting from the engine-shed, 60 feet in depth and 63 feet in front: in the middle of this front is an entrance for locomotives in communication with the up line; and on either side are the offices for this department, including a waiting-room for the engine-men, store-room, office, turnery, wood-room, and coke-heating oven. In the centre of the engine-shed is a turn-table 15 feet in diameter, from which sixteen lines radiate to as many sides; two of them being continued without the building to join the main lines; the one for the out-going, the other for the in-coming engines: each radial line of way will hold two engines. The centre portion of this building is without a roof, a plan which appears to us as presenting many inconveniences. A sky-light, with proper means of ventilation, would, we think, answer the purpose much better. The side circular portion is covered with a light iron roof.

On each side of the out-going line is a circular shaft into an arched passage below, for the purpose of raising the coke therefrom. This passage communicates with the coke-vault, which being nearly on a level with the Canal, the coke is readily transferred to it from the barges. Along the middle of the arched passage a single line of way is laid down with a gauge of 18 inches: on this the coke is moved from the cellar, by means of small

trucks, to underneath the eyes or shafts above mentioned. The vault being at right angles to the passage, a small turn-table is placed at the meeting of the two lines in the middle of the vault; the second line runs down to the Canal. The coke-vault is arched, is about 300 feet long, 30 feet wide, and 20 feet high, and is calculated to hold about 1,400 tons of coke. The communication between the locomotives' shed and the vault beneath is by means of a flight of 27 steps, each rising $8\frac{1}{4}$ inches.

COKE.—The coke introduced at this establishment is from Worsley, from Harecastle, from Messrs. Cave and Morris's near Warrington, and from Lord Vernon's, and also from Kenworthy's, near Ashton. A boat-load is equal to about 17 tons. The price of coke at Worsley is 25*s.* a ton; and the freight to Birmingham 138*s.* a load, making the price per ton of Worsley coke delivered at Birmingham about 33*s.* The Harecastle coke is also 25*s.* a ton at the ovens; but the freight is, of course, much less. The above cokes are mixed in equal proportions for all except the mail-trains. For the mail-trains, Worsley and Warrington cokes are used. Several tons of this coke are sent daily to Wolverton, and there again mixed with the Camden depôt coke, which is made by the Company from Newcastle coal, as already described at page 232. The refuse-coke is used with wood for lighting the fires of the locomotives, the coke being first heated in an oven for that purpose.

In the Birmingham coke-department there are eleven men, at 3*s.* a day, constantly employed, six by day and six by night, besides the foreman. In the Birmingham locomotive-engines' department there are six fitters, three smiths, three strikers, one joiner, one turner, one painter, one boiler-maker, twenty-eight cleaners, five boys, two clerks, a day-watchman and a night-watchman, nine engine-drivers, and as many firemen or assistants.

The buildings of the above establishment are lighted at night by twenty gas-burners, about twelve of which are required in the vault and passage by day also.

In arranging an establishment of the above description, it is very desirable to avoid, if possible, any thing like a daily increased expenditure, which, in the present instance, is caused by gas-lights being required for the day as well as night.

BIRMINGHAM GOODS-DEPÔT.—The goods-depôt at Birmingham is separated from the station by Curzon Street: the communication from the station and main line to the depôt is by means of a double way, altogether 55 feet wide, passing between the Birmingham and Grand Junction stations, and crossing Curzon Street on a level, and at a very acute angle, so that the gates on each side of this street, which are hung so as to close either the railway or street, as may be required, are of the extraordinary width of seventy-six feet. The average length of this depôt is about 490 feet, and the average depth 382 feet.

The goods-warehouse is a rectangular building, situate between the railway and Curzon Street; it is 250 feet in length and 78 feet in depth, with five doorways in front, and as many turn-tables without, and on the line of way nearest to the building. From these turn-tables short lines run into docks, properly constructed within the warehouse, for the loading and unloading of goods. The common road-wagons are loaded and unloaded by means of loop-holes at the back of the warehouse.

There are four lines of way in front of the warehouse, and eleven cross lines at right angles to the main lines. The turn-tables are of 8 feet and 9 feet 2 inches diameter respectively, and about thirty-five in number.

At a distance of 50 feet from the end of the warehouse the engineer's and other offices are situate, being at the extreme end of the railway. This building is 88 feet in front, and the centre portion is 45 feet deep. There is also a row of small offices near the entrance-gates for the use of carriers. A range of stables occupies the angle of the depôt immediately opposite to the entrance. On the right line of way entering the depôt there is a weigh-bridge and office, the size of the platform of which is 9 feet 3 inches by 5 feet 2 inches. There is also a gauge for regulating the height of loaded wagons: this gauge is 6 inches lower than the lowest arch under which the wagons have to pass.

CARRIAGE DEPARTMENT.—On the 1st January, 1840, the number of first-class carriages was 107; of second-class, open, 137; of second-class, closed, 36; of mails, 15; of carriage-trucks, 66; of horse-boxes, 44; of parcel-vans, 2; and of post-offices, 3. Third-class carriages have lately been introduced, for the convenience of the poorer class of passengers.

The first-class carriages are in three compartments, lined and stuffed within, with elbow-divisions on each seat, and furnished with small lamps by day as well as by night, on account of the numerous tunnels. Each carriage will hold eighteen persons. The total weight of a first-class carriage is 76 cwt. The length of the body is 16 feet, and including buffers, 20 feet; the width of body is 6 feet 6 inches, and including steps, 8 feet 2 inches; the body is 4 feet 11 inches high, and the body and under-frame together 5 feet 10 inches.

The second-class carriages in general use are open at the sides and closed at each end, and roofed in. These are also in three compartments, and will hold twenty-four passengers. The weight of a second-class open carriage is 51 cwt. The body is 13 feet 6 inches long, and extreme length, including buffers, 16 feet 4 inches; the width of body is 6 feet 1 inch, and extreme width, including steps, 8 feet; the height of the body is 5 feet 3 inches, and including under-frames, 6 feet 1 inch.

The second-class closed carriages (used with the night-trains) are in three compartments, and will hold the same number of passengers as the last-named; they have glass sashes, and are entirely enclosed, but have no cushions nor linings within. The weight is 62 cwt. The body is 13 feet 2 inches long, and extreme length 17 feet; the width of the body is 6 feet 4 inches, and including steps, 8 feet; the height of the body is 5 feet 3 inches, and including under-frame, 6 feet 4 inches.

The mails, which are fitted up in a style of great comfort, are in three compartments, including a coupé in front. Each mail is furnished with an imperial on its roof, and a lamp within each compartment. The number of passengers a mail will hold with the coupé is ten. The weight is 72 cwt. The length of a mail is 16 feet, and extreme length 19 feet 7 inches; the width of body 5 feet, and extreme width 8 feet 2 inches; the height of the body is 4 feet 11 inches, and including under-frame, 5 feet 11½ inches.

The carriage-trucks are 14 feet long and 7 feet 4½ inches wide, and the extreme length, with buffers, is 17 feet 1 inch. The weight of a carriage-truck is 43 cwt. The carriages are secured to the trucks by means of movable cross-bars fitted into the side-frames, and placed close to the wheels of the carriages; and further secured to one of the wheels by a chain having a right and left-hand screw-fastening. The springs are secured by leather straps to the wheels, to prevent oscillation.

The horse-boxes will each hold three horses, separated from each other by a movable bar. The length of a horse-box is 10 feet, and including buffers 13 feet 2 inches; the width is 7 feet 3 inches; and the height of the body and under-frame together is 8 feet 1 inch; the weight being 2 tons 10 cwt.

The parcel-vans each weigh 67 cwt. These are entirely enclosed, having folding-doors on one side. The length of the body is 15 feet 5 inches, and extreme length, with buffers, 21 feet 1 inch; the width of the body is 7 feet 7 inches; and the height of body and under-frame, 7 feet 5 inches.

The post-office is fitted up in two compartments; the one as the sorting-room, and the other chiefly for the letter-bags, which are distributed and collected at the different places along the line. The sorting-room is fitted up with a mahogany counter and drawers; above the counter are several tiers of shelves with vertical divisions, forming small compartments for the proper arrangement of letters and newspapers, each compartment having the name of the place neatly labelled on the outside, for which the letters or newspapers are respectively intended.

The assistant has a small desk or counter in the bags' compartment, and also a contrivance of net-work without, for receiving the letters from the different postmasters along the line without stopping the train. The bags are also left at the requisite places while the train is in motion.

We had an opportunity last winter of accompanying one of the post-office clerks for some miles on his journey; and he most politely explained to us the whole system of sorting, leaving, and collecting the letters, which appeared to us susceptible of very little improvement. But one thing forcibly struck us, viz. the necessity of warming this carriage, which, during the winter months, is miserably cold.

The length of the post-office is 16 feet, and including buffers 18 feet 9 inches; the width is 7 feet 6½ inches; the height of body 6 feet 6 inches, and including under-frame, 7 feet 6 inches. The weight is 4 tons 1 cwt. 2 qrs. The weight of the clerks, bags, &c. is estimated at 2 tons 7 cwt. 3 qrs.

The post-office is accompanied by a tender, something similar to a horse-box in size; its weight is 2 tons 7 cwt. 3 qrs. The gross weight of the post-office establishment is taken at 9 tons 1 cwt., according to Appendix No. 9 of the Second Report of the Select Committee on Railways.

The wheels used are all of wrought iron, 3 feet in diameter, with $2\frac{1}{2}$ -inches journals; and are chiefly furnished by Mr. Hague, of Rotherhithe; Messrs. Losh, Wilson, and Bell, of Newcastle; and Messrs. Bramah and Fox, of Birmingham.

The carriage-department is at the Euston station, and consists of a brick building in two floors, 175 feet 6 inches long and 98 feet 6 inches wide. The ground-floor, which is on a level with the railway, will hold sixty carriages on cross lines of way, which are in communication with the railway by means of a central line running the whole length of building. Turn-tables are placed at the several intersections, and also in front of the entrance-doors. The upper floor is for the building, repairing, and painting of the carriages, and contains also the office of the superintendent.

The number of men in the carriage-department is about 110. The repairs of coaches for twelve months, ending 30th June, 1840, amounted to 17,813*l.* 5*s.* 4*d.*

WAGONS, &c.—At the beginning of 1840 the number of wagons was about 489, including 100 with closed sides, 200 for cattle, and four double sheep-wagons. About 200 of the first-built wagons are furnished with Hague's cast-iron wheels, weighing 8 cwt. 2 lbs. per pair, and costing 20*l.* a set. Those of Bramah and Fox, Birmingham, and Losh, Wilson, and Bell, of Newcastle, are also used; the latter weigh 8 cwt. 3 qrs. 27 lbs. per pair, and cost 29*l.* per set.

The truck-wagons contain each about 26 cubic feet of oak, and 70 feet superficial of $1\frac{1}{4}$ -inch deal; the luggage-wagons, 127 feet of $1\frac{1}{4}$ -inch deal, 37 feet of 1-inch deal, and 6 feet 2 inches cube of oak, for corner-pieces, ledges, &c. The total weight of a truck as above is 2 tons 3 cwt. 2 qrs.; of a ballast-wagon, 2 tons. The cost of a wagon is about 65*l.*, including wrought-iron wheels by one of the best makers.

The brass bearings for the journals weigh each 3 lbs. The steel springs are furnished by Mr. Lowe of Birmingham, Mr. Spencer of Newcastle, and others, and cost about 6*d.* a lb. The hook-plates are of iron, $\frac{1}{4}$ of an inch thick, 18 inches long, and $4\frac{1}{2}$ inches wide. The ends of soles are bound with $\frac{1}{4}$ -inch iron. The soles are secured to the cross-pieces by bolts, 10 inches in length.

The capacity of a wagon is equal to about 120 cubic feet.

The weight of iron-work in a wagon is as follows :—

	ton.	cwt.	qrs.	lbs.
Four wheels	0	17	0	0
Four grease-boxes (cast)	0	1	1	0
Four 3-feet springs	0	2	0	24
Four axle-guards, 1½ inches square	0	1	1	8
Draw-bar, 1½ inch square, with hook and four links	0	3	0	4
Brake and guard	0	0	3	10
Bolts, screws, nuts, &c.	0	7	0	0
Eight spring-clips	0	0	0	16
Eight spring-ties	0	0	0	16
	<u>1</u>	<u>12</u>	<u>3</u>	<u>22</u>

The wagons are built and repaired at the Camden depôt, in buildings especially used for the purpose, close to Chalk Farm Lane, with an entrance from the Hampstead Road.

TRAINS.—There are altogether fourteen trains leaving London daily, except on Sundays, ten of which run through to Birmingham, one to Rugby, two to Aylesbury, and one to Wolverton. There are also ten daily trains running from Birmingham to London, one from Wolverton to London, two from Aylesbury to London, and one from Rugby to London. The distance, therefore, daily run over by the Company's passenger-engines is 2,683·50 miles, except on Sundays, when it is 778·50 miles. On Sundays there are three down-trains running through to Birmingham, and one to Wolverton; and three up-trains to London, and one from Wolverton to London. Thus the total distance run over in a year by the passenger-engines with trains is at the rate of 830,387·50 miles.

There are two mail-trains daily in each direction; that in the morning from London at 9^h 45^m, and that in the evening at 8^h 30^m; and from Birmingham, the morning-mail leaves at 8^h 30^m, and the night-mail at 12. The total distance is performed by the mail-trains in five hours. The first-class train is allowed 5½ hours, and the mixed trains 5½ hours each; the third-class train is allowed 8¾ hours. The tickets are taken at the Camden depôt on the arrival of the trains at London, and at the bridge over the Canal at Birmingham.

FARES, AND PASSENGER-TRAFFIC, &c. — The charge per passenger by the mail-carriage for the whole distance is 32*s.* 6*d.*, which is nearly the maximum allowed by the Company's Act, being at the rate of 3·474*d.* per mile; the first-class fare is 30*s.*, or at the rate of 3·207*d.* per mile; the second-class fare is 20*s.*, or 2·138*d.* per mile; and that for the third-class passengers 14*s.*, or 1·496*d.* per mile.

During the first months of 1838, the line being opened only to Tring, the number of passengers travelling on this railway averaged about 357 per diem. On the further opening to Denbigh Hall, and from Birmingham to Rugby, the average daily number was about 1786; but it was during the summer and part of the autumn months. When the whole line was opened, the number for the first seven months averaged about 1304 per diem. From June 1st, 1839, to January 31st, 1840, the number of passengers conveyed amounted to 437,159·50, being at the rate of 1028·61 per diem. From the first opening of the line to June 30th, 1840, the total number of passengers amounted to 1,088,435. At the present time the traffic is truly astonishing, the receipts averaging upwards of 14,420*l.* per week, or nearly at the rate of 750,000*l.* per annum, from 1st January, 1840.

LOCOMOTIVE ENGINES. — The engines used both for the passenger and goods-traffic on this railway are all mounted on four wheels* (see Table No. XI. of British Locomotive Engines, in the Appendix). The whole number of engines in this service at the beginning of the year 1840 was

* Mr. Bury having been requested by the Select Committee on Railways to furnish a statement of the reasons he had to assign for his preference of four-wheeled engines, submitted, among others, the following:—The four-wheeled engine is less costly than that on six wheels; it can be got into less space; is much lighter, and therefore requires less power to take it up the inclines, and consequently leaves more available power to take up the train; is safer, as it adapts itself better to the rails, not being so likely to run off the line at curves or crossings; is more economical in the working, there being fewer parts in motion, and consequently less friction; those parts of the machinery which are common to both plans are more easily got at in the four-wheel engine; the buildings and turn-tables are not required to be on so large a scale; as there are fewer parts in the four-wheel engine, fewer tools, as lathes, drills, &c., are required; having fewer parts to be deranged, stoppages are not so likely to take place on the journey.

eighty-two; of this number the passenger-engines numbered from 1 to 36; and from 49 to 52 have 12-inch cylinders and 18-inch stroke; and from 37 to 48 inclusive, 13-inch cylinders and 18-inch stroke. From 61 to 90 are all coupled merchandise-engines, which are occasionally used for the passenger-trains by removing the couplings (see Elevations of the two descriptions of Engines, Plate VI.). The turn-tables for these 4-wheeled engines are each of 11 feet diameter.

Besides the above engines there are several ballast-engines, the proportions of which will also be seen by reference to the same Table: except the "Harvey Combe," they have each four coupled wheels.

We found the average weight of thirty-two passenger-trains on this line (see Table I. of Results of Practical Experiments) to be 93,837 lbs., the average speed to amount to 24·67 miles per hour, and the stoppages to occupy on an average each 3·66 minutes.

Mr. Bury, who is the superintendent of the locomotive department, has prepared an analysed account of the work done by, and the cost of working, the locomotive engines from the 1st January to 15th December, 1839, inclusive.

The number of passenger-engines employed in this service was thirty-nine, and of goods-engines thirty. The total number of miles run by the passenger-engines amounted to 475,842, or on an average to 12,201·76 miles by each. The number of tons gross conveyed one mile amounted to 21,158,796, or 542,533·23 tons by each engine. The coke consumed in the same period amounted to 18,229,232 lbs., or on an average at the rate of ·86 lb. per ton per mile. The cost of coke for the same period amounted to 15,212*l.* 2*s.* 4*d.*, being equal to 37·38*s.* per ton, or ·17*d.* per gross ton per mile. Thus the number of miles run by the passenger-engines averaged 1363·44 per diem, or at the rate of 34·96 miles by each engine; and the cost of coke averaged 43*l.* 11*s.* 8·88*d.* per day.

There were thirty goods-engines at work during the above period. The total number of miles run by this class of engines amounted to 239,156, or on an average to 7971·86 miles by each. The number of tons gross conveyed one mile amounted to 17,527,439, or 584,247·96 tons by each engine. The coke consumed in the same time amounted to 10,077,872 lbs.,

or on an average at the rate of $\cdot 57$ lb. per ton per mile. The cost of coke for the same period amounted to 8,343*l.* 7*s.* 1*d.*, being equal to $\cdot 11$ *d.* per ton per mile.

Thus the number of miles run by the merchandise-engines, excluding Sundays, averaged 799·85 per diem, or at the rate of 26·66 miles by each; and the cost of coke averaged 27*l.* 18*s.* 1*d.* per day.

Again: taking the passenger and goods-engines together, the whole number of engines at work amounted to sixty-nine; the number of miles run to 714,998; and the number of tons gross conveyed one mile to 38,686,235. The consumption of coke was 28,307,104 lbs., or on an average at the rate of $\cdot 70$ lb. per ton per mile. The number of miles run by the engines averaged 2163·29; and the cost of coke 71*l.* 9*s.* 9·98*d.* per day respectively.

The total expenditure for the above period in the locomotive department (excluding the Aylesbury line) was 48,365*l.* 13*s.* 3·35*d.*, or at the rate of 138*l.* 0*s.* 2·50*d.* per diem; of this sum, the coke averaged 71*l.* 9*s.* 9·98*d.*; the enginemen's wages, 13*l.* 16*s.* 1*d.*; the repairs of engines, 18*l.* 4*s.* 9·45*d.*; the repairs of tenders, 1*l.* 19*s.* 0·26*d.*; and the charge for oil, hose, pipes, fire-tools, and files, amounted to 32*l.* 10*s.* 5·81*d.* per diem.

THE ESTABLISHMENT.—In March 1840, the establishment consisted of the secretary, the superintendent of the locomotive and mechanical department, the general superintendent, and the following heads of departments, clerks, and messengers: viz. in the secretary's and finance-department, eighteen; audit-department, ten; locomotive department, three; coaching and parcels-department, forty-eight; goods-department, seven; stores-department, eight; superintendent's department, three; together, ninety-seven persons.

Independently of the above, there are employed in the coaching-department, including police, four hundred and forty persons; in the coach-repairing department, one hundred and twelve; in the construction-department, forty; and in the stores-department, twelve.

In the locomotive-engine department—four hundred and forty-eight artificers, including thirty-five engine-drivers, twenty-eight firemen, and twenty-five pumpers; besides forty-three labourers and three watchmen.

In the fixed-engine department at Camden Town—one engine-man, one stoker, one rope-splicer and assistant, one sheeves-oiler, and two cleaners.

In the engineering-department—one consulting engineer, three resident engineers, one draftsman, and one architect.

In the London division, which extends from London to Wolverton, there were six overlookers, seven time-keepers, seven joiners, three smiths, three strikers, two painters, three engine-men, four firemen, three cleaners, eight fitters, two greasemen, and thirty labourers.

In the Birmingham division, which extends from Wolverton to Birmingham, there were six overlookers, seven time-keepers, two joiners, four smiths, two strikers, two engine-men, three firemen, three cleaners, two fitters, two greasemen, one switchman, and fifteen labourers.

In the coke-department there were altogether thirty persons employed, including the foremen and fifteen labourers.

In the carrying-department there were three joiners, four brakesmen, two lamp-lighters, and eight labourers.

Thus the total number of persons employed in this vast establishment amounted, in March 1840, to thirteen hundred and ninety-five. This, too, is exclusive of waymen, who are paid by the contractors for keeping the permanent way in repair.

The whole of the permanent way is kept in repair by two contractors, Mr. T. Jackson and Mr. John Cummins; the former having from London to Rugby, at 345*l.* per mile, and the latter from thence to Birmingham at 300*l.* per mile. These two contracts amount together to 37,496*l.* per annum, on an average, or at the rate of 333·29*l.* per mile.

In the latter part of 1839 we counted as many as eight waymen, on an average, per mile. In some parts of the way, boxes of plate iron for the workmen's tools are placed on one side of the line, about one in each mile. The size of a tool-box is 6 feet long by 3 feet wide, and 2 feet 8 inches high.

The whole cost of the undertaking up to 30th June, 1840, is comprised in the following items:—

Land and compensation	£706,152	5	2
Railway works and stations	4,287,646	18	10
Engines and tenders, tools and implements	146,910	5	11
Coaches, trucks, wagons, &c.	189,187	4	5
Acts of Parliament	72,868	18	10

Law-charges, conveyancing, engineering, advertising, printing, } direction, office-expenses, salaries, and sundries . . . }	167,983	3	11
Interest on loans, previous to general opening on the 17th Sep- } tember, 1838 }	127,493	0	6
Debenture charges	133	7	0
	<u>£ 5,698,375</u>	<u>4</u>	<u>7</u>

It is to be observed that the item of land and compensation includes property for which the Company receive rent: the sum of 3156*l.* 6*s.* 11*d.* had been received on this account for one year, up to 30th June, 1840. The whole cost per mile, according to the above statement, is 50,652*l.*, of which the works and stations amount to about 38,112*l.*; the land and compensation to about 6,276*l.*; the carriages, trucks, wagons, &c., 1,681*l.*; and the engines, tenders, &c., 1,305*l.* per mile respectively. Taking these four items together, which constitute the net cost of the railway and furniture, the sum per mile amounts to about 47,376*l.*

ORIGINAL ESTIMATE.—The following is the original estimate as prepared for the Lords' Committee, when this line was before Parliament in 1832:—

Excavations and embankments	£ 779,000
Tunnelling	250,286
Bridges	350,574
Rails, chairs, pins, and keys	£ 212,940
Blocks and sleepers	102,960
Ballasting and laying rails	102,960
Fencing, at 740 <i>l.</i> per mile	76,032
	<u>494,892</u>
Land	250,000
Six water-stations, at 500 <i>l.</i>	3,000
Six intermediate pumps	600
Two depôts	16,000
Forty locomotive engines and tenders	40,000
Three hundred wagons, at 30 <i>l.</i> each	9,000
Sixty coaches, at 200 <i>l.</i> each	12,000
	<u>2,205,352</u>
Contingencies	294,648
Total estimated cost	<u>£ 2,500,000</u>

The expenses of working the line for one year, ending 30th June, 1840, are exhibited in the following statement :—

Maintenance of way, including slips, &c.	£ 80,763	13	11
Locomotive power, including salaries, wages, coal, coke, oil, tallow, waste, &c.; expenses of pumping engines at stations; repairs of engines and tenders; superintendence; and all other charges	69,003	11	9
Police-account, including wages, clothing, &c.	22,243	9	1
Coaching-account, including salaries, wages, clothing of guards and porters, gas, oil, tallow, and stores	47,611	9	4
Merchandise-department, including salaries, wages, incidental expenses, and repairs of wagons	5,319	16	2
Stores-department, including salaries, &c.	1,948	15	1
General charges, including law-proceedings, advertising and printing, direction, office-charges, sundries, including travelling-expenses	13,453	5	11
Rates and taxes	13,434	7	3
Mileage-duty to government	22,848	9	1
Accident-account	1,154	10	6
	277,781	8	1
Fund for depreciation of locomotive engine and carriage stock	26,338	0	0
Interest on loans for twelve months	115,848	2	2
Rent of Aylesbury line for one year	2,500	0	0
Total annual cost	£ 422,467	10	3

Thus the cost of maintenance of way amounts to 221*l.* 5*s.* 4½*d.*; locomotive power to 189*l.* 1*s.*; coaching-department to 130*l.* 8*s.* 10*d.*; police-establishment to 61*l.* 4*s.* 3½*d.*; goods-department to 14*l.* 11*s.* 5½*d.*; stores-department to 5*l.* 6*s.* 9½*d.*; rates and taxes to 36*l.* 16*s.* 1½*d.*; mileage-duty to government to 62*l.* 11*s.* 11½*d.*; accident-account to 3*l.* 3*s.* 3*d.*; and interest on loans to 344*l.* 16*s.* per diem respectively.

The following shews the different items of revenue for the year ending June 30th, 1840 :—

Passenger-traffic	£ 505,479	9	8
Conveyance of mails	14,676	16	1
Conveyance of parcels	41,784	2	7
Conveyance of horses, carriages, and dogs	31,738	7	8
Conveyance of merchandise	91,335	18	7
Conveyance of cattle	2,089	14	0
	£ 687,104	8	7

According to the above account, the gross receipts amount, on an average, to 1,384*l.* 17*s.* 6*d.*; conveyance of mails to 40*l.* 4*s.* 2½*d.*; conveyance of carriages, horses, and dogs, 86*l.* 19*s.* 1*d.*; conveyance of merchandise to 250*l.* 4*s.* 8½*d.*; conveyance of cattle to 5*l.* 14*s.* 6*d.*; and conveyance of parcels to 114*l.* 9*s.* 6½*d.* per diem respectively.

The profit for the year ending 30th June, 1840, amounted to 278,338*l.* 7*s.* 6*d.*, which is equal to 9·278*l.* per cent on the paid-up capital in the first half year of 2,875,000*l.*, and in the second half year of 3,125,000*l.*

We cannot conclude the account of this extraordinary work, without recording the great assistance we have received from Richard Creed, Esq., the indefatigable secretary of the Company, who has, from time to time, afforded us every facility for examining the works and stations, and furnished us with such data as were necessary to render the account as accurate as possible.

LONDON AND BLACKWALL RAILWAY.

THERE is, indeed, but little credit due to an engineer who simply follows the beaten track of those who have gone before him; neither is it a wise plan, if he wishes to take high rank in his profession. If a man is not possessed of ability and talent sufficient to overcome ordinary difficulties which naturally arise in the course of a long practice, he is unfit to be called a civil engineer.

Our examination of the Blackwall Railway, a work displaying considerable ingenuity and originality of contrivance, led to the above remarks.

The peculiar locality in which this line is situate precluded the use of the ordinary modes of working a railway. Passing through a densely populated district, with no fewer than five intermediate stations in the distance of about three miles and a half, the locomotive engine could not have been profitably employed; the low speed at which it must necessarily have travelled, and the time absorbed by the stoppages, added to the danger attendant upon

~~the burning coke~~ flying about among the roofs of the contiguous houses,—all ~~presented~~ themselves as impediments in the way of its adoption: neither ~~could the engineers~~ avail themselves of the other method—we allude to the ~~fixed-engine~~ system as ordinarily used; for, although the carriages could have been thrown off at the intermediate stations without stopping, as they are by the plan at present in use on this line, yet they could not have been taken up between the termini without much more extensive arrangements at each station, and a considerable loss of time in performing the journey. Several plans had been proposed to effect a railway-communication between the East and West India Docks and London previously to the one now under consideration.

About sixteen years ago we were engaged for Mr. Walker, engineer to the Commercial Road Trustees, in preparing plans and sections for a railway to be laid down on the present line of road. This plan, however, afterwards ~~merged~~ into a granite tramway,* which is at present in use, from the West India Dock entrance to the top of the Commercial Road.

Another plan was proposed for carrying a railway nearly on the surface of the ground from Church Lane, Whitechapel, to run midway between the Commercial and Mile End roads; the eastern terminus of which was to have been a little to the north of the Barking Road Bridge, over the river Lea, with a branch to the West India Docks, and another to a projected floating pier off Sir R. Wigram's wharf at Blackwall. This line was surveyed by Messrs. Dale and Hemming, under the direction of Mr. M. J. Brunel.

A third project was that of Messrs. Stephenson and Bidder, engineers of the present railway; which was to carry a line from the East India Company's warehouse on the north side of Leadenhall Street, crossing Whitechapel between Red Lion Street and Church Lane, and passing thence in a

* On the 12th March, 1829, Mr. Walker, in the presence of C. H. Turner, Esq., chairman of the road-trustees, and the chairman and deputy-chairman of the West India Dock Company, made some experiments with regard to the proper load for a horse on this tramway. They were tried on that part of the road lying between the West India Dock entrance and the first toll-gate, a length of 550 feet, the average rise of which is 1 in 155. The result of these experiments was stated in a report by Mr. Walker to be, that he considered six tons gross as the proper *up*-load for a London draught-horse; the tramway rising altogether towards London. We may here mention rather a curious coincidence: Mr. Bidder, one of the engineers of the Blackwall Railway, superintended for Mr. Walker the whole of the works connected with the stone tramway.

perfectly direct line a little to the south of the Barking Road Bridge, with a branch to the Brunswick Wharf, and another to the West India Docks. This line was intended to have been carried considerably below the surface of the streets, between retaining walls, from the London terminus as far as Rhode's Well, Stepney, and thence on embankment and viaduct to its eastern terminus.

The original south line, called the Commercial Railway, as proposed by Mr. Jeffery, and approved of by Sir John Rennie, followed nearly the course of the present line; but was intended to have been carried at an average elevation of about 24 feet above the surface of the streets; and, for about half a mile at Limehouse, at the enormous height of 35 feet above the surface: so that the original estimate would, in all probability, have been doubled, had the scheme been carried out according to this plan.

In 1837, Mr. Cubitt was engineer to the Blackwall Railway Company. In the session of that year they applied for an Act to extend their line from the Minories to Lime Street; but it was violently opposed by the St. Katharine's Dock Company and the Corporation of London, and was thrown out. In 1839, however, this Company's application to Parliament for the extension to Fenchurch Street was successful; and in the course of another year this important part of the line will, no doubt, be in active operation. The royal assent was given to the Act of incorporation on the 28th July, 1836, and authorised the Company to raise a capital in joint-stock of 600,000*l.*, and by loan 200,000*l.* additional. The number of shares is 24,000, each of 25*l.*; and up to the present time (Nov. 5th, 1840) four-fifths have been paid up.

COURSE OF THE RAILWAY. — Leaving the intended station in Fenchurch Street, the line crosses Crutched Friars and the Minories to the present station on the east of that street, and on the south side of Goodman's Yard; it thence runs, with a curve of about 3000 feet radius, for a length of about 170 yards, and continues on the north of Rosemary Lane and Cable Street, crossing Cannon Street Road at a distance of about 366 yards from the Commercial Road; thence nearly parallel to Back Road for about 766 yards, and continuing in nearly a direct line to within a short distance of White Horse Street, which is crossed at about 43 yards south of the Commercial Road; the line thence takes a curving course for about 1166 yards, to near Lime-

house Causeway, the radius being of one mile. In this length it passes between the Regent's Canal Basin and the Commercial Road, and crosses the Lea Cut, Church Lane, and Three Colt Street. From the end of the length above described it recurves, with a radius of about 3800 feet, for a length of 900 yards, crossing the West India Dock Road, and passing between Poplar High Street and the West India Dock warehouses; from whence it is traced in a direct line to the north of the Brunswick Tavern, and passing between this building and the south-west angle of the East India Export-dock, terminates at the station on the Brunswick Wharf.

INCLINATIONS.—Commencing at Fenchurch Street, the following exhibits the lengths and inclinations of the several planes:—

Distances from the London terminus. yards.	Length of each Plane. yards.	Ratio of Inclination.	Locations.
593·33 . . .	593·33 . . .	descending at the rate of 1 in 150	
858·33 . . .	265·00 . . .	descending „ 1 in 400	White Lion Street.
1179·00 . . .	320·67 . . .	ascending „ 1 in 210	Princes Place.
1848·33 . . .	669·33 . . .	descending „ 1 in 330	Cross Street.
2343·33 . . .	495·00 . . .	level	Davenport Street.
2593·33 . . .	250·00 . . .	descending „ 1 in 320	Stepney Causeway.
2823·33 . . .	230·00 . . .	descending „ 1 in 200	White Horse Street.
3175·00 . . .	351·67 . . .	descending „ 1 in 175	
3448·33 . . .	273·33 . . .	descending „ 1 in 200	Island Lane.
3666·66 . . .	218·33 . . .	descending „ 1 in 106	Church Lane.
3745·66 . . .	79·00 . . .	descending „ 1 in 480	Three Colt Street.
4056·66 . . .	311·00 . . .	descending „ 1 in 180	Limehouse Causeway.
4276·66 . . .	220·00 . . .	ascending „ 1 in 1400	W. I. Dock Road.
5166·66 . . .	800·00 . . .	descending „ 1 in 108	Harrow Lane.
5790·00 . . .	623·34 . . .	descending „ 1 in 1870	
6123·33 . . .	333·33 . . .	ascending „ 1 in 150	Blackwall station.
Total . 6,123·33 yards.			

Thus the total length of the line is 3 miles 843 yards, and the number of planes sixteen: of which twelve are descending from London, and amount in length to 6123·33 yards, three ascending, and one level. The gradients, it will be seen, are chiefly of the second class. From the level of the rails under Brunswick Street, Blackwall, which is about the lowest part of the line,

to the London terminus, a distance of 16,850 feet, the total rise is 68 feet, which gives an average inclination of 1 in 247·79.

VIADUCT AND BRIDGES. — That portion of the line lying between the Minories and the West India Dock Road is carried by a handsome viaduct of brick, at a considerable elevation above the levels of the streets intersected by it. The whole length of this viaduct is 4020 yards, and the number of arches 285, chiefly of 30-feet span and semi-elliptical form, having a versed sine of 10 feet. The arches are constructed of five rings, but shew only three on the face, which gives the entire structure a light appearance. The whole top surface of arches is coated with a thick layer of asphalte, which will, no doubt, keep the arches water-tight: a similar precaution in the case of the Greenwich viaduct* would have saved that Company a considerable outlay in the shape of repairs, besides rendering the arches available for stores, &c. A stone weathered cornice, of bold outline, runs the whole length, and on either side of the viaduct; this is also used as a blocking-course, in which are fixed the iron standards of the railing, very properly introduced instead of solid parapets, the ill effects of which are daily experienced on the Greenwich Railway: the noise to the passengers is of a stunning description, and the constant destruction of the parapet-copings must have entailed a considerable outlay for repairs. The standards on the Blackwall Railway are of cast iron, of neat design, with pedimented caps; the principal standards are 3 feet 7 inches high, and 10 inches wide. The intermediate standards are of less size and height. The whole are fixed at intervals of 8 feet 6 inches from middle to middle; two cast-iron rails, of 1½ inches diameter, run the whole length of the viaduct, passing through proper circular openings left in the standards for that purpose. The height of the top rail from the level of the blocking is 3 feet. The piers are generally 3½ feet in thickness. In crossing the principal streets and roads, iron girder-bridges are introduced, which afford an equal height from one side of the street to the other, and present an exceedingly neat appearance. There are five girders to each of these

* This plan is at present being carried into effect for a length of a quarter of a mile at Deptford (see Greenwich Railway description).

crossings, which take their bearings on brick abutments and projecting stone brackets. The largest arches are those which cross over the Regent's Canal locks; they are three in number, and each of 87-feet span. There is also an arch of similar span carrying the railway over the Lea cut. The whole width of the viaduct is 26 feet, and the average height about 19 feet.

Besides the viaduct above described, there are three girder-bridges at Blackwall, which severally carry Preston's Road, Brunswick Street, and the Brunswick Wharf Road over the railway; and there is likewise a neat wooden foot-bridge over the railway at Harrow Lane, Poplar.

The extension-line from the Minories to Fenchurch Street will also be carried on arches, crossing in its course the following streets, viz. Vine Street, Gould Square, Cooper's Row, and Crutched Friars.

EARTHWORKS.—The line is carried by an embankment from the east side of the West India Dock principal entrance to Preston's Road, a distance of rather less than half a mile; and towards the Blackwall terminus it passes through slight cutting. The top width of the embankment is 21 feet 5 inches; and the average width of way, where the line is in cutting, and between the retaining walls, near the East India Export Dock, is 30 feet 5 inches.

GAUGE OF WAY, &c.—The gauge adopted on this line is the same as that of the Eastern Counties Railway, viz. 5 feet; the intermediate space is 5 feet 5 inches, and each side-space 4 feet 10 inches, making the clear width between the railings 25 feet 1 inch.

The rails used are of the single parallel form, 5 inches deep, and $2\frac{1}{4}$ inches wide on the top surface, being similar to those used on parts of the Manchester and Leeds, and on the Chester and Bickenhead Railways (see Plate III. figs. 9 and 45). The mode of securing them to the chairs is also the same, being by a ball and key. Cross sleepers are used throughout. The ballasting consists of Thames gravel, and also of gravel dug from pits, and is of the full width of the railway, and two feet above the crowns of the arches.

STATIONS. — Besides the station in the Minories and that at Blackwall, there are five intermediate stations, which are situate at Shadwell, Stepney,

Limehouse, the West India Dock entrance, and Poplar. The station in the Minories presents a plain elevation next that street, and extends for a depth of about 130 yards. It consists of a large entrance-hall and booking-office on the level of the Minories, and a considerable extent of passenger-shed on the level of the railway. The platform on either side is of wood, between which there is a double line of way, with two traverses or crossings. The staircases, which lead from the booking-office to the platforms for the departure-passengers, are quite distinct from those by which the arrival-passengers leave the station. These latter descend into an open passage on either side of the building, which lead to gateways in the Minories. Underneath the platforms and railing of this station are the engine and boiler-houses, to which there is a distinct entrance from Goodman's Yard.

The Blackwall station is on a very extensive scale; and the arrangements appear to be well suited for the peculiar system of working this railway. The two lines of way are distinguished throughout as *the north line* and *the south line*. At this station the north and south lines are separated from each other by a stone platform running down the middle line of the sheds. The south line is stopped by this platform, which is returned at the west end of the offices; and the north line is produced along the whole length of the shed, which runs at the back of the offices, and is extended to within 17 yards of the Dock-entrance. There is also an additional line or carriage-siding running the whole length of the shed. These two lines under the north shed terminate on two turn-tables, each of 13 feet diameter. The roofs are of light appearance, being constructed of iron rafters, braces, and ties.

The sheds are well lighted by large sky-lights in the roofs; and in one part the covering consists entirely of glass.

The offices, which front the Brunswick Wharf, present a striking elevation when viewed from the river. The river-entrance is in the middle of this front, and opens into a spacious hall, from which a doorway facing the entrance leads into a very extensive booking-office: on the right of the hall are the superintendent's apartments, and on the left the gentlemen's waiting-room and conveniences; a staircase of good proportions leading to the upper floor ascends from this hall, under which is the porter's pantry and coal-store.

The booking-office has a counter extending the whole length. At each

end is a door leading on to the platforms, and also a corresponding door opening into the ladies' and gentlemen's waiting-rooms.

On the upper floor is a very large room, not less than 37 yards in length and 15 in width, extending the whole length of the offices, which is intended for the use of the foreign steam-boat passengers and their luggage while being examined by the proper officers of the Customs. There are two loop-holes in the river-side of this apartment for taking in the luggage; and a large trapway over the railway, from which it can be let down into the wagons, or on to the roofs of the carriages.

The Shadwell station is situate on the east side of Church Road, and consists of a temporary booking-office under one of the arches, a wooden staircase on each side of the viaduct, and a platform, also of wood, on either side of the railway. There is also a police-box at the west end of the south platform, in which is placed the apparatus belonging to the telegraph.

The Stepney, Limehouse, and West India Dock stations, which are respectively situate at White Horse Street, Three Colt Street, and the West India Dock entrance, correspond with each other in point of general design and arrangement. The office in each case is situate under one of the arches. A staircase on either side ascends to the north and south platforms, which, as regards the passengers, are kept quite distinct from each other. The station is entirely covered by a cottage-roof, which extends from the outer wall on one side to that on the other.

The Poplar station, which is approached by two curved roads from Preston's Road, is on quite a different plan. The booking-office is altogether over the railway and platforms, so that passengers have to go up stairs to get their tickets before they can start by the railway. This arrangement was rendered necessary in order to prevent the necessity of passengers crossing the line from one platform to the other. The whole width of way between the platforms of the intermediate stations is 18 feet 10 inches; and the height of the platform above the level of rails 2 feet 2 inches. The platforms and stairs are of stone, the walls of brick, and the roofs are covered with slate.

STATIONARY ENGINES. — The railway is worked by a pair of marine condensing engines placed towards either end of the line: those for the up-traffic being placed under the level of the railway at the station in the Minories,

and being each of 115-horse power; and those for the down-traffic being each of 74-horse power, and placed in a building specially erected for the purpose on the west side of the Brunswick Wharf Road at Blackwall. The former were erected by Messrs. Maudslay and Field; and the latter by the Horsley Company, under the immediate superintendence of Mr. Barnes. The usual working pressure is $4\frac{1}{2}$ lbs. on the square inch. A small engine for maintaining a vacuum in the condensers is already fixed in the London engine-house; and there will also be one for the same purpose fixed in the engine-house at Blackwall. The whole distance between the engine-stations is about 5466 yards, or 3.105 miles.

The London engines having to draw the loads *up* the line are necessarily much more powerful than those at Blackwall. Besides those in daily use, there is a pair of extra engines of equal power at each end of the ropeway, to be used as occasion may require. The driving-wheels, which are fixed on the shaft of the engines, are each 17 feet in diameter, 22 inches on breast, having eight arms, and furnished with 120 teeth, which work into those of a cogged wheel on the shaft of the rope-drum: the cogged-wheel is 10 feet 10 inches in diameter, and 2 feet 3 inches on breast, having cogs of wood. Between this cogged wheel and the rope-drum, and on the same shaft, is a brake-wheel $15\frac{1}{2}$ inches wide, furnished with a proper friction-band of iron. The large rope-wheel or drum is constructed of cast iron, and is 23 feet in extreme diameter, and 3 feet 8 inches in extreme width: the central part of this wheel consists of six main arms running from the axle to the under side of the hollow rim or rope-groove. There is also an intermediate circular ring, from the outer periphery of which to the under side of the rope-groove semi-arms are introduced to strengthen the whole. In order to give sufficient strength to the hollow rim by the introduction of feathers on the outside, the internal width is considerably reduced from the outer circumference to the bed, otherwise it would have been much better to have the inside of the flanches or sides vertical, as the rope would not have been so liable to slip.

The ropes at present in use are of $5\frac{1}{2}$ inches circumference, weighing 8.816 lbs. per yard, or about 40 tons each. A short length of the patent metallic rope, of one inch in diameter, is introduced towards the Blackwall end. The rope on either line runs over cast-iron sheeves in the usual way,

which are fixed in the central line between each pair of rails. The whole length of each rope is equal to twice the distance between the engine-stations, added to about fourteen turns of the rope on each drum; so that while the rope is being wound on the drum at one end, it is unwinding on that of the other; the rope is, therefore, passing up and down the line with but little intermission during the whole of the working hours. In order to prevent the rope from twisting, swivels are introduced at convenient intervals. Small intermediate rollers fixed between the sheeves would tend much to save the rope from wearing when it trails on the boards, which is frequently the case while in motion.

The cast-iron sheeves are, for the most part, each of 3 feet diameter, and $7\frac{1}{2}$ inches wide, and turn on spindles, which revolve in proper cups fixed on the sides of the boxes or frames.

At each end of the line towards the engine-house, wooden drums or rollers of 20 inches diameter, and 2 feet 7 inches between the flanches, are used instead of the ordinary sheeves: this allows the rope to have the required play as it approaches the large rope-wheel. The whole number of metal sheeves on one line of way between the engine-houses is 493, besides the wooden rollers, of which there are three at the London end, and two towards the Blackwall engine-house. Thus the average distance between the sheeves in the same line is about eleven yards. Where the line is curved the sheeves are of different form, the external diameter being 3 feet, the internal diameter 2 feet 6 inches, and the width $7\frac{1}{2}$ inches. This method prevents the necessity of fixing the sheeves in an inclined position, as it gives the rope a play of 3 inches vertically and 6 inches horizontally. There are also some sheeves of 2 feet 6 inches diameter, and 8 inches wide. The greatest care appears to have been taken throughout to prevent the rope from slipping off the sheeves.

We may notice here a single wooden sheeve on the south line, the thirty-first to the east of the Poplar station. It consists of two pieces of circular elm properly turned, and each of 3 feet diameter, which may be called saucers, the bottoms of which are united together by a counter-sunk iron hoop passing round the smallest circumference of each. A proper bush is secured to the centre of the wheel in which the spindle is fixed, and the whole revolves in metal cups or bearings, as above mentioned. This con-

struction of sheeve is very likely to come into general use, as it appears to answer its purpose satisfactorily, and can be supplied at a less cost than those of cast iron.

It remains only to mention the mode of working the passenger-carriages by the new system. We may suppose the engines and ropes at rest, and the ropes lying over the sheeves on each line: it has already been mentioned that there are five intermediate stations, at each of which a carriage starts on the up-trip simultaneously with those at the Blackwall terminal station. For this purpose each carriage is attached to the rope, as will be hereafter explained; and the proper signals being given and answered throughout by means of the electro-galvanic telegraph, the London engines are put in motion, and the rope, with nine carriages attached, is drawn up the line. The Shadwell carriage first arrives at the London station; then, after an interval of time in proportion to the distance between these stations, that from Stepney, and so the other intermediate carriages in order, and lastly two carriages from Blackwall—one carriage having been left at the Stepney, and another at the Shadwell intermediate stations.

The down-train leaves the London station with seven carriages, the last of which is to be left at the Shadwell station. This is readily managed by the guard (who stands in front of the carriage) taking out a pin from the coupling at an interval of time sufficient to let the carriage arrive at its proper destination by the momentum acquired in its passage from London. The Shadwell down-carriage is now stationary, and its passengers alight. The same process is repeated at Stepney, Limehouse, the West India Docks, and Poplar; and now the train is reduced to two carriages, which continue attached to the rope, until arriving near the divergence from the rope-line near the engine-house, where they are thrown off, and run up the terminal incline to the Blackwall station by the impulse acquired while attached to the rope.

The number of down-trains daily is fifty-one, and up-trains fifty; the ropes, therefore, travel 155·25 miles on the up-line, and 158·35 miles on the down-line, or altogether 313·60 miles daily. The weight of each rope is about 40 tons; the carriages, with the ordinary number of passengers, which we find to have averaged twelve to each carriage since the opening, or about one ton in weight, weigh each about $5\frac{1}{2}$ tons gross. As four of the carriages travel from Blackwall to Stepney, three to Shadwell, and two to the Minories,

besides one carriage from each of the intermediate stations to the Minories, the proportional weight of carriages for the whole distance up is 34·21 tons, and the gross load 74·21 tons. The number of revolutions of the rope-wheel per minute is 40, the average circumference of the rope-track while being wound on the wheel 57·60 feet, and the whole distance between the engine-houses 16,398 feet; the time occupied in drawing up the load will therefore be 7·116 minutes, or at the rate of 26·18 miles per hour.

In the down-trip seven carriages travel to Shadwell, six to Stepney, five to Limehouse, four to the West India Docks, three to Poplar, and two to Blackwall; the proportional weight of carriages therefore for the whole distance is 26·76 tons, and the gross load, taking the rope as before, is 66·76 tons.

Now the number of up-trips, as above, is 50, and of down-trips 51; so that the gross load moved the whole distance daily is equal to 7115·26 tons, or 22,092·88 tons moved one mile.

We were informed that the consumption of coal for the London engines is 7 tons, and for those at Blackwall 5·35 tons daily, or together 12·35 tons. The cost per ton at Blackwall is 16s. The description of coal is Derwent, Newcastle. The amount per annum for coals, taking the above weight and price, would be 3,606*l.* 4s.

The persons employed in this service are two engine-men, two stokers, two cleaners, and two drummers, for each engine-station, besides five sheeves-men, whose duty it is to fill up the grease-boxes along the line daily. About 80 lbs. of grease is consumed per week.

CARRIAGES.—The carriages in use on this line consist of first-class, mixed, and third-class.

The first-class carriage consists of four compartments, each of which will hold ten persons, or forty in all; its length is 20 feet, and width 7 feet 6 inches; it is mounted on six wrought-iron wheels of 3 feet diameter, and is furnished with improved springs, each 3 feet 9 inches from point to point.

The mixed carriages consist of two central first-class and two end Stanhope compartments. The first-class compartments will each hold ten passengers; and the Stanhope compartments each twenty, or sixty in all.

A third-class, or Stanhope, is 18 feet in length and 7 feet 6 inches

wide, and will hold about seventy persons. It is entered by four doors, which open into as many compartments of equal size, formed by two wooden bars, one running down the middle of its length, and the other across from side to side. We were astonished to see several most respectably dressed persons riding in the Stanhope compartments, which are intended especially for those who cannot afford to pay for better accommodation.

All the carriages are furnished with two lever-brakes, one at either end, and on opposite sides. There is also a disconnecting or throwing-off apparatus at one end of each carriage, and a coupling of three links at the other, with two eyes in the outer link, through which, and a corresponding eye attached to the adjoining carriage, the pin passes, and can be drawn out at pleasure. Two guards or brakemen accompany each carriage, whose duty it is to disconnect the carriages from each other, and to throw off the carriage from the rope. The throwing-off apparatus will be better understood by referring to Plate XVI.

The first-class compartments are fitted up with every regard to the comfort and convenience of the public; but are wanting in elbows, which would sometimes be exceedingly convenient to keep one aloof from an unpleasant fellow-traveller. The journey, however, is but of short duration.

The carriages are all painted dark blue, and have the Company's arms emblazoned on the panels: they are from the works of Mr. Wright, who has obtained considerable celebrity for the manner in which he builds and finishes railway-carriages.

FARES AND TRAFFIC, &c. — The fare for a first-class passage from the Minories to Blackwall, a distance of 3·47 miles, is sixpence, or at the rate of 1·729*d.*; and for a standing-place fourpence, or at the rate of 1·152*d.* per mile respectively. The tickets are taken of the passengers as they enter the carriages. We are exceedingly glad to find that the admirable system of ticketing invented by Mr. Edmondson, and first used on the Newcastle and Carlisle Railway, is adopted on this line.

The line was opened to the public on the 6th July, 1840, since which time, for a period of 95 days, the number of passengers amounted to 648,310, or at the rate of 6,824 per diem, which is equal to 2,490,760 per annum. The receipts for the same period amounted to 9,767*l.* 17*s.*, being at the average rate of 102*l.* 16*s.* 4½*d.* per diem, or 37,528*l.* 11*s.* 4½*d.* per annum.

By referring to Messrs. Stephenson and Bidder's Report of the 6th January, 1838, we find the estimated number of passengers taken at 8,000 per diem. This, no doubt, will be nearer the number when the line is opened to London Street.

The following exhibits the cost of the undertaking up to the 30th June, 1840:—

General expenses previous to the 31st December, 1838	£ 61,664	2	2
Works	214,573	14	4
Carriages, on account	5,000	0	0
Property purchased, including vendor's costs and conveyancing	330,814	9	9
Parliamentary agency, counsels' fees, solicitors' charges, &c.	10,142	12	11
Engineering	£ 4,662	10	7
Surveying, on account	2,026	13	11
		6,689	4 6
Direction	3,000	0	0
Salaries	1,955	0	0
Rent, furniture, maps, plans, &c.	1,007	3	11
Rates, taxes, and insurance	2,490	18	1
Advertisements	273	7	9
Petty cash and miscellaneous	452	17	2
Interest on debentures and stamps	£ 1,449	8	6
Interest on loans	3,815	1	2
Discount on calls in advance	15	9	11
		5,279	19 7
		£ 643,343	10 2

We have devoted considerably more space than we had originally intended to the account of the Blackwall Railway; we found it necessary, however, to extend its limits, in order to give the shareholders and the public a correct view of this important work. The general arrangement of the machinery is due to the talent of Mr. George Stephenson; and the ingenious method of throwing off and disconnecting the carriages, and the working of the passenger-traffic, to Mr. Bidder. The works throughout are executed in the most substantial manner. No extraneous ornament is introduced in any part; and the design of the whole reflects the greatest credit on the eminent engineers whose services the Company were so fortunate in obtaining. We consider this railway, from its peculiar locality, and from the economical mode of working it, likely to prove one of the best investments

of the day. The principal buildings are from the design of Mr. Tite, president of the Architectural Society.

We must not omit to mention briefly the beautiful apparatus of Messrs. Wheatstone and Cook, by which instantaneous communication is effected between the terminal stations, or between any one station and any other on the line. Without this, one of the most splendid inventions of modern times, the working of the Blackwall Railway according to the present system would have been rendered rather hazardous.

There are three persons employed at the terminal stations to work the electro-galvanic telegraph, each of whom attends nine hours a day, which time is separated by an interval of four hours, as it requires too much attention on the part of the manipulator to enable him to remain at it for nine hours consecutively. At the intermediate stations it is the duty of the policemen to attend to the signals, which are very easily understood and readily managed. There will be altogether about twenty miles of wire to work effectually the signals on this short railway.

LONDON AND BRIGHTON RAILWAY.

PARLIAMENTARY contests are never carried on without a great sacrifice of money.* How much more judicious a plan would it be for parties interested in competing lines of railway to refer the selection of the best plan to competent and disinterested engineers "out of doors," and thus leave the course in the various stages of its progress through Parliament comparatively clear, and uninterrupted by vexatious and unnecessary opposition!

There cannot be a more easy task allotted to an engineer, who is

* The cost of the parliamentary contest for the Brighton Railway is shewn as under:—

Rennie's line	.	.	.	.	.	.	. £72,000
Stephenson's	.	.	.	.	.	.	. 53,750
Cundy's	.	.	.	.	.	.	. 16,500
Gibbs'	.	.	.	.	.	.	. 26,325
South-Eastern, about	.	.	.	.	.	.	. 25,000
							£ 198,575

thoroughly conversant with railway matters, and has the details of each laid before him, than to select from two or more projected lines of railway that which ought on all accounts to be chosen.

Had such a method been adopted with regard to the various lines projected to Brighton, a large sum of money would have been saved for the more useful purpose of constructing the great works which had to be encountered in effecting a railway through the natural barriers between London and Brighton. As it is, the *direct* line has been chosen; but a more difficult and expensive one could not have been selected. Many of the engineering works are of a formidable character, and are necessarily prosecuted by night as well as by day, in order to open a portion of it as early as possible, according to the intention of the Board of Directors.

As a forced march through a rugged country is attended with considerable fatigue to soldiers encountering it, so a forced passage for a railway through any district, however easy, for the purpose of effecting a premature opening, is alike attended with considerable risk to the traveller, and an unnecessary sacrifice of funds on the part of the proprietary. In the present instance, the plea of drilling the officers and servants of the Company, as usually put forth, would avail nothing, as the Shoreham Branch affords ample accommodation in this respect. We might adduce numerous illustrations of the above remarks; but the fact is too well known to require our insisting on it here at greater length.

ACTS OF PARLIAMENT, &c. — The Act for the incorporation of this Company received the royal assent on the 15th July, 1837, and authorised a capital to be raised in joint-stock of 1,800,000*l.*, and by loan an additional sum of 600,000*l.*, making together 2,400,000*l.*

The number of shares is 36,000 of 50*l.* each.

COURSE OF THE LINE.—Leaving the London and Croydon Railway at a distance from London of 9 miles 22 chains, the line proceeds in a curvilinear course to the left of Croydon; thence running to the right of Coulsdon, and on the east of the turnpike-road, to Merstham, as far as Hooley Lane, where it is within a few yards of the road. It thence continues through Merstham Chalk Hill by a tunnel, and to within a short distance and on the left of Reigate, near to which place the South-Eastern Railway diverges; thence through

the parishes of Horley, Worth, and Balcombe, in which last it passes under ground by the second tunnel. From this point it continues to within $1\frac{1}{2}$ miles of Cuckfield, and one mile of Linfield, from whence it is traced through Clayton Hill by the third tunnel, and intersects the parishes of Patcham and Preston, to its termination at Church Street, Brighton; the whole length of the main line being 42 miles 33 chains, and the distance from the London terminus of the Greenwich Railway 51 miles 55 chains. The distance to Shoreham from the main line is $5\frac{1}{2}$ miles; so that the whole length of railway is 47 miles 73 chains.

The inclinations and lengths of the planes, commencing at the Croydon junction, are as follows:—

Lengths of Planes.				Ratio of Inclination.		Locations.
Miles.	Chains.					
	42·64	. . . . .	ascending	at the rate of 1 in 823		
	20·00	. . . . .	level.			
8	42·00	. . . . .	ascending	„ 1 in 264		Merstham summit.
	60·00	. . . . .	descending	„ 1 in 800		
6	69·00	. . . . .	descending	„ 1 in 264		
2	30·00	. . . . .	ascending	„ 1 in 546		
4	05·00	. . . . .	ascending	„ 1 in 264		Balcombe summit.
4	35·36	. . . . .	descending	„ 1 in 264		
4	00·00	. . . . .	descending	„ 1 in 391		
1	56·00	. . . . .	level.			
3	40·00	. . . . .	ascending	„ 1 in 264		Clayton summit.
5	33·00	. . . . .	descending	„ 1 in 264		Brighton.
42	33·00					

Thus the whole length of the main line is not quite $42\frac{1}{2}$ miles. The prevailing and ruling gradient is 20 feet. The whole length of planes graduated with this incline is 32 miles 64·36 chains, being more than three-fourths of the whole distance. This line comes under the second class in point of gradients. There are three summits: the first is at Merstham, 9 miles 24 chains; the second at Balcombe, 23 miles 28·64 chains; and the third at Clayton, 37 miles, respectively from the Croydon junction.

EARTHWORKS.—The earthworks are of an extraordinary character, the cuttings amounting altogether to not fewer than 6,861,683 cubic yards, or at

the rate of upwards of 156,000 cubic yards per mile, independent of the tunnels, the excavations from which are thrown to spoil on the surface of the ground near the several working shafts.

In July, 1839, according to Mr. Rastrick's report, there were as many as 4769 men and 570 horses engaged in the removal of earth; in January, 1840, there were altogether 4370 men employed, 695 horses, and five locomotive engines; and in July following, there were 6206 men and 960 horses, besides five locomotives.

The Merstham tunnel north cutting is the largest work in this department, amounting to nearly a million of cubic yards, principally of chalk, a great proportion of which is carried to spoil.

The principal embankments are those of Earl's Wood Common and Vale Pool, containing each about half a million of cubic yards.

The following statement shews the amount of earthwork in each of the several contracts:—

Nos.	Name of Contract.	Cubic yards.
1	Croydon	209,425
2	Coulsdon	466,494
3	North Merstham	587,203
	Diversions of turnpike-roads . .	18,543
4	Merstham tunnel.	
5	South Merstham	839,381
6	Horley	392,873
7	Worth	503,399
8	Balcombe tunnel.	
9	Balcombe	436,125
10	River Ouse viaduct.	
11	Cuckfield	549,409
12	Vale bridge	553,710
13	Keymer	720,000
14	Clayton tunnel.	
15	Patcham	712,000
16	Preston	341,121
17	Shoreham branch	290,000
18	Brighton	242,000
	Total	<u>6,861,683</u>

The top width of embankments is 24 feet.

BRIDGES, VIADUCTS, AND TUNNELS.—The whole number of bridges over and under the railway amounts to ninety-nine. They are built chiefly of brick, with stone dressings. The stone is partly from the Heddon quarries near Newcastle-upon-Tyne. The arches over the railway are of 30-feet span, five rings in thickness, and 16 feet in clear height. The clear width between the parapets of bridges carrying the railway over roads is 27 feet 10 inches, and the parapets $1\frac{1}{2}$ bricks in thickness.

The largest viaduct is over the Ouse Valley, which is 462 yards in length, and about 60 feet high; the number of arches being thirty-seven.

The principal tunnels are at Merstham, Balcombe, and Clayton Hill. The Merstham tunnel is through chalk, which is raised to the surface of the ground by double horse-gins, one at the top of each of twelve vertical shafts; from whence the skiffs are moved on small trucks, by means of tramways, and their contents deposited in spoil-banks. Mr. Rastrick describes the ground in the Balcombe-tunnel as very treacherous, requiring great caution on the part of the miners in working it, as "it swells and effloresces as soon as exposed to the air."

The estimated cost of the whole of the tunnels is 150,000*l*.

GAUGE OF WAY, &c.—The rails are set at about 4 feet 9 inches apart, which allows of sufficient play for the wheels, and is now far more usual than 4 feet $8\frac{1}{2}$ inches. The intermediate space is 6 feet 5 inches; and each side-space of ballasting 2 feet 9 inches; making the whole width of ballasting about 21 feet 6 inches. The width of land enclosed on a level is about 24 yards.

The rails are in 15-foot lengths, and of the double parallel form (see Plate III. fig. 39), weighing 76 lbs. to the yard, and are set in heavy chairs, measuring $10\frac{1}{2}$ inches by $5\frac{1}{2}$ inches for the joint, and $10\frac{1}{2}$ by $4\frac{1}{2}$ inches for the intermediate points of support. They are fixed partly on cross sleepers, and partly on stone blocks; the bearings are 3 feet 9 inches. Where blocks are used, felt is introduced between the chairs and the stone. The chairs have three perforations, two on one side, and one on the other, through which the spikes are driven to connect the chairs with the blocks or sleepers, the block-holes being previously plugged with wood. The rails are secured to the chairs by wooden keys, those for the joints being 6 inches long, and

measuring $2\frac{1}{2}$ inches by $1\frac{1}{2}$ inches, and the intermediate keys having the same scantling, but being only $4\frac{1}{2}$ inches long.

The ballasting, where the line is completed near the Croydon junction, is of large-sized gravel.

The fencing is of stout wooden posts bound with iron at top, and three rails. There is also a vertical intermediate stay between each pair of posts, which renders the whole sufficiently strong. The quicks are planted on a bank between the field-ditch and that at the bottom of the embankment-slope.

The following shews the various items of expenditure up to 30th June, 1840, and the estimated cost of the whole undertaking:—

Parliamentary expenses	£ 4,240 0 11
Land and compensation	350,423 1 8
Works: contracts	466,839 5 8
Rails and chairs, stone blocks, sleepers, and kyanizing	273,553 11 7
Engines and tenders, carriages, wagons, and trucks	10,282 12 6
Engineering and surveying	23,323 13 3
Law-expenses	8,311 10 5
Direction	6,300 0 0
Police	4,746 7 2
Office-expenses, including salaries, stationery, postage, and petty expenses	8,025 18 3
Advertising, printing, and engraving	2,885 7 8
Travelling and incidental expenses	1,989 0 9
House, No. 10 Angel Court	4,147 2 4
Commission and stamps	1,472 18 6
	<hr/>
	£ 1,166,540 10 8
The estimated sum required to complete the railway, and to provide stations, engines, carriages, &c. and for meeting every other expense incident to the opening of the line throughout, on a liberal scale is	633,459 9 4
	<hr/>
	£ 1,800,000 0 0

Thus the cost per mile will be at the rate of 37,568*l.* 17*s.* 6·30*d.*; whereas at the first general meeting of the Company, it was stated in the directors' report that the whole cost of the undertaking, including buildings, stations, and every contingency, would not exceed 1,120,000*l.*, or 23,376*l.* 3*s.* 9·52*d.*

per mile, according to the estimates of Messrs. Rennie and Rastrick, and which estimates had been examined by Mr. Locke, who had also made a personal survey of the line. Thus the excess over the revised estimate, according to the above statement, is 680,000*l.*, or at the rate of 14,192*l.* 13*s.* 8·78*d.* per mile.

The Shoreham branch, which was opened to the public on the 12th of May, 1840, is stated to have cost 150,000*l.*, or at the rate of 27,272*l.* 14*s.* 6·54*d.* per mile. Thus the main line from the Croydon junction to Brighton, a distance of 42·412 miles, will, according to the present estimate, amount, on an average, to 38,904*l.* 1*s.* 8·10*d.* per mile.

In 105 days, the number of passengers travelling on the Shoreham branch amounted to 69,583, giving an average of nearly 663 per diem; and the average receipts per diem amounted to 22*l.* 10*s.*

The description of locomotive engines used on this line will be seen by reference to Table XII. of British Locomotives, in the Appendix.

LONDON AND CROYDON RAILWAY.

NOTWITHSTANDING the tremendous outcry in Parliament against the Croydon Railway, on account of the New Cross incline of *one in one hundred*, for a length of nearly *two miles and three-quarters*, it has now been successfully worked for upwards of fifteen months; and were it not for the New Cross station being located exactly at the bottom of this incline, there would generally be no need of an assistant-engine. When, however, the Brighton and South Eastern Railways are opened, the traffic of which is intended to pass over the Croydon line, it will be advisable for the down-trains to stop as seldom as possible at this intermediate station; and if the loads are properly regulated, the assistant-engine may be, in a great measure, dispensed with. At present it answers the double purpose of leading the coal-trains from the Company's wharf near New Cross to Croydon, and assisting the passenger-trains up the lower portion of the incline.

ACTS OF PARLIAMENT, &c.—The Act of incorporation received the royal assent on the 12th June, 1835, and authorised a capital in joint stock to be raised of 140,000*l.*, in shares of 20*l.* each, and an additional sum by loan of 45,000*l.*, but which has since been capitalised. A second Act was passed in the following session, and is dated 14th July, 1836, by which the Company were empowered to make an addition to the capital of 100,000*l.*, also by 20*l.* shares. The third Act received the royal assent on the 11th June, 1838, by which a gross sum of 300,000*l.* was authorised to be raised; of which 160,000*l.* was to be by 20*l.* shares, and the remainder by loan. Thus the whole sum authorised by the Company's Acts amounts to 585,000*l.*

The following is a copy of a paper delivered in to the Select Committee on Railways :—

Capital of the London and Croydon Railway Company, 30th April, 1839.

October 1835 . . .	7000 shares at 20 <i>l.</i> each	£140,000
July 1837 . . .	7000 „ 14 <i>l.</i>	98,000
April 1838 . . .	6000 „ 15 <i>l.</i>	90,000
February 1839 . . .	6666 „ 10 <i>l.</i> 10 <i>s.</i>	69,990
Total of shares		397,990
„ Bonds		75,700
Further powers		54,300
		<u>£ 527,990</u>

COURSE OF THE LINE.—The country through which this railway passes is remarkably picturesque. The general direction is that of the old Canal, which was purchased by the Croydon Railway Company; the greater portion of it has been drained to make room for the railway. Leaving the Greenwich Railway at rather more than 1½ miles from the London station, with a curve of about 2¼ miles radius, it passes to New Cross; thence to Brockley, Forest Hill, Sydenham, Penge Common, within about 1½ miles and to the east of the Beulah Spa, Norwood, and thence continues to the Croydon station in the London road. The whole line is curvilinear; but with the exception of that at the Croydon station, which has a radius of less than half a mile, the curves are unobjectionable throughout.

INCLINATIONS.—Having an incline of 1 in 100, this railway comes under

the second class in point of gradients. The following shews the lengths and inclinations of the line, commencing at the junction with the Greenwich Railway :—

Lengths of Planes.		Ratio of Inclination.		Locations.
Miles.	Chains.			
	41·15	. . . . .	ascending at the rate of 1 in 4744	
	57·63	. . . . .	ascending „ 1 in 1311	New Cross station.
2	50·36	. . . . .	ascending „ 1 in 100	Dartmouth Arms station.
	34·40	. . . . .	level.	
	34·55	. . . . .	descending „ 1 in 2591	Sydenham station.
1	4·70	. . . . .	ascending „ 1 in 660	
	46·30	. . . . .	level.	
1	29·13	. . . . .	descending „ 1 in 660	
	41·50	. . . . .	ascending „ 1 in 823	
	40·97	. . . . .	level	Croydon.
8	60·69			

By the above table it will be seen that the inclinations are peculiarly favourable, with the exception of the New Cross incline; and had it been possible to have introduced a level plane of only a quarter of a mile in length in the middle, it would have added greatly to the facility of working both the up and down-trains.

EARTHWORKS.—The report of Mr. Cubitt, the consulting engineer, dated March 9th, 1840, states the total cost of the earthworks to have been 84,218*l.* 16*s.*, including slips and extra slopes, or at the rate of upwards of 9624*l.* per mile. The New Cross cutting is the chief work in this department, the quantity of earth removed amounting to upwards of half a million of cubic yards. The produce of this cutting was partly led to form the embankment between New Cross and the Greenwich junction; and a great proportion of it is deposited in spoil-banks.

BRIDGES.—The bridges throughout are of neat design, and the construction very creditable: they are chiefly built of brick, including the viaduct at Corbett's Lane at the junction with the Greenwich Railway. The bridges over this railway are generally of 30-feet span; and the lowest clear height

above the rails in the centre of the way is $14\frac{1}{2}$ feet. Six of the bridges over the railway are of novel design, and present a very light appearance. That over the railway at Forest Hill may be mentioned as an illustration. It consists of seven segmental arches; the central one, which is over the railway, being of about 30-feet span and 27 feet 6 inches high; and the abutment-arches being each 12 feet in span, and of correspondent height to the soffits. The novelty consists in the main arch springing from the pier of the two adjoining arches on each side instead of from its own, the spandrils above the haunches being left open.

The bridge at New Cross over the railway has a very neat appearance; the arch is a flat segment of 30-feet span, with a versed sine of only 2 feet 3 inches, and is constructed of cast-iron ribs, which are secured together by wrought-iron ties passing from side to side. The abutments, wing-walls, and parapets, and also the faces of the arch, are all constructed of good brick-work, with stone dressings. A person approaching this arch for the first time is struck with its apparent flatness; but so soon as he passes beneath and looks upwards, he discovers the deception.

The bridges are altogether eighteen in number, exclusive of the viaduct adjoining the Greenwich Railway. The total expenditure in the bridge-building department amounted to 47,649*l.* 4*s.* The bridges are numbered throughout.

Besides the bridges, there are six large culverts, the chief of which are at New Cross and Sydenham.

LEVEL ROAD-CROSSINGS. — The high roads crossed on a level by the railway are that from Dulwich to Bromley, at the Dartmouth Arms station, and another at the Jolly Sailors' station: at each of these places a policeman is constantly stationed, who attends to the folding-gates, which shut either across the railway or road, as required. Guard-rails are introduced at the level field or occupation-crossings.

GAUGE OF WAY, &c. — The gauge of way is 4 feet $8\frac{1}{2}$ inches; the intermediate space 6 feet 5 inches; and the side-spaces (beyond the Jolly Sailors' station) each 9 feet wide: the top width of embankments is thus 33 feet 10 inches.

The rails are of the broad-based T-form (see Plate III. fig. 40), in 15-foot lengths: they are laid throughout on longitudinal sleepers 9 inches wide by 5 inches thick, having a layer of felt between the wood and the rails. The rails are secured to the sleepers by $\frac{1}{2}$ -inch screw-bolts, the inner ones being 4 inches long, and counter sunk; and the outer ones $4\frac{1}{2}$ inches long, the heads being an inch in diameter and $\frac{1}{2}$ an inch thick. The screws are introduced in pairs at intervals of about 19 inches, and are at right angles to the top surface of the flanch, which is considerably inclined. At the joints four screws are used nearly close to each other: there are 20 screws to each 15-foot rail. The longitudinal timbers are fixed on cross sleepers 9 feet in length, and having a scantling of 9 inches by $4\frac{1}{2}$ inches, and secured thereto by $\frac{1}{2}$ -inch spikes 9 inches in length. The whole of the timber is kyanized, and a considerable portion is also coated with tar.

The ballasting consists of broken stone, brick-rubbish, and gravel, and is laid on the whole width of embankments.

The distance-posts are of wood, of arris-form, presenting two faces towards the railway, on which the distances from London and Croydon are respectively marked: they stand 2 feet 3 inches above the ground, and are placed at intervals of a furlong each—a division which is not adopted on any other railway we are acquainted with. This plan might be advantageously followed on every line, the gradients of which are under those of the first class, for the purpose of ascertaining the relative velocities, &c. in ascending and descending the inclines.

STATIONS AND DEPÔTS.—Besides the terminal stations of London and Croydon, there are six intermediate stations, viz. at New Cross, Forest Hill, Sydenham, Penge, Anerley Bridge, and Norwood.

The London station is quite apart from the railway itself, being situate on the north side of, and contiguous to, the London station of the Greenwich Railway. In consequence of the trains having to pass along the Greenwich Railway for $1\frac{1}{2}$ miles before reaching the Croydon line, the utmost care and vigilance are required to prevent collision with the Greenwich trains. A signal-house is, however, placed at the junction; and by judicious arrangements, accidents from the above cause seldom occur.

The London station, which is necessarily elevated on arches to the height of the Greenwich Railway, is about 100 feet in width, and on an average 300 feet in length, the area being about 40,000 superficial feet. The offices are beneath the level of the railway, and are entered from Joiner Street. There are separate staircases from the booking-offices for the first and second-class passengers; and the departure-gate from the station opens on to the sloped approach of the Greenwich Railway. The passenger-shed is 170 feet in length and about 48 feet in width, covering a triple way on the side next the Greenwich Railway: the roof is supported by fourteen cast-iron columns; and on the other side by a brick wall, with piers and arches, which sufficiently relieve it from the bareness a blank wall presents to view. The triple way on leaving the station diverges into the Greenwich double way just beyond the crossing of Dean Street. A traverse frame is used at this station instead of turn-tables, for transferring the carriages from one line to another. This station is to be exchanged for that of the Greenwich Railway, so soon as the new double way is completed to Corbett's Lane; which arrangement will prevent the necessity of the two lines crossing each other.

The New Cross station is rather on an extensive scale, occupying about $2\frac{1}{2}$ acres of ground. The most prominent feature of this station is the locomotive engine-house, which, with the carriage repairing-shed, occupies the central portion of the area. The engine-house is octagonal, being built within a circle of about 105 feet diameter. It has a central turn-table, from which lines of way diverge in radial lines to the different sides. The carriage-house and repairing-shed abut on the north side of the engine-house, and are in connexion with each other by a single line of way. On the west side of the station is a convenient smithy, and other offices occupying the north-west angle. There is a separate entrance for the workmen, close to which is the timekeeper's lodge.

The booking-office and passengers-shed are on the up-side of the railway. The passengers-shed is somewhat similar to that at the London station; but it is evidently misplaced. It ought to have covered the railway, instead of being on one side. On the east side of the station is the pumping engine-house and coke-shed; and detached from these is the engineer's office.

It is certain that this station is of far too costly a description for so short a line of railway; at least one acre of ground might have been dispensed with, and the buildings should have presented a less imposing appearance. The sum of upwards of 21,000*l.*, which it is stated to have cost, is really a large amount to have been thus expended.

The Croydon station and depôt are co-extensive with the basin, wharfs, &c., originally occupied by the Canal Company, and extend to nearly five acres of ground.

The entrances to the station and depôt are both next to the London road. The booking-office and corridor extend from the side of the north entrance to the passenger-shed, a length of about 130 feet. There are two lines of way under the passenger-shed, with an arrival and departure platform, as at the London and New Cross stations. There is also a locomotive engine-shed, a pumping engine-house, and smithy, as also a warehouse, and workmen's cottages, with an office for the engineer.

The intermediate stations are of neat design, but of far too costly a description throughout.

CARRIAGES. — The carriages consist of first and second-class vehicles of the ordinary construction, the first class being in three compartments, and holding altogether eighteen passengers; and the second class also in three compartments, and holding altogether twenty-four passengers. Each carriage is mounted on four wheels.

FARES, TRAFFIC, &c. — Each train is usually made up of two first and two second-class carriages: the stopping and starting of the trains is well managed; and punctuality of departure and arrival are strictly attended to.

We found the average weight of nine trains, taken in June, July, and December 1839, to amount to 44,651 lbs. gross; the average velocity to be at the rate of 20·78 miles an hour; and the stoppages to occupy each on an average ·72 minute (see Table K of Results of Practical Experiments, in the Appendix). At the present time (November 1840) there are ten down-trains daily with passengers, and eleven up-trains; and on Sundays ten trains in each direction.

The fares of first-class passengers from London to Croydon, a distance

of $10\frac{1}{4}$ miles, were originally at the rate of about $2d.$ per mile; and of second-class passengers, for the same distance, about $1\cdot50d.$ per mile. The present charges for first-class passengers are, however, at the rate of $2\cdot34d.$; and for second-class passengers $1\cdot75d.$ per mile respectively.

For eight months, ending January 1840, the number of passengers conveyed on this line amounted to 369,311; the receipts on this account for the same period amounted to 20,783*l.* 4*s.*: the proportion of second to first-class passengers was nearly as 5 to 1. From the 1st February to October 8th, 1840, inclusive, the number of passengers amounted to 398,911 $\frac{1}{4}$; and the receipts for passengers, merchandise, and parcels, for the same period to 25,078*l.* 0*s.* 10*d.* Thus the average number of passengers for the whole period amounted to 1548·83; and the average gross receipts for the last eight months to 99*l.* 18*s.* 3*d.* per diem respectively.* The line was opened to the public on the 5th June, 1839.

LOCOMOTIVE ENGINES.—All the engines used on this line have six wheels. By reference to Table XIII. of British Locomotives, in the Appendix, their description and proportions will be readily seen.† According to the present number of trains, the distance travelled by the passenger-engines is equal to 78,033 miles per annum.

From the statement of original cost of this work, independent of land, parliamentary and law expenses, and engineering, as set forth in Mr. Cubitt's report above alluded to, we collect the following items, viz. :—

Earthworks	£ 84,218	16	0
Fencing, draining, and preparing for ballasting the way	15,043	4	1
Bridges	47,649	4	0

* The following are some of the Company's charges for the carriage of goods, &c. :—

To and from Croydon and the Company's Wharf at the Surrey Canal, a distance of eight miles, for coal, iron, metals of all kinds, and all other heavy materials, 4*s.* 6*d.* per ton; and to and from London and Croydon (the distance being $10\frac{1}{4}$ miles), for furniture, bale-goods, china, glass, groceries, &c., 10*d.* per cwt. Wheat, beans, pease, tares, rye, linseed, turnip-seed, &c., 10*d.* per quarter; and for barley, malt, oats, and light grain, 8*d.* per quarter.

† Since this table was printed, another engine, by name Coryndon, has been added to the stock, which is from the works of Messrs. Chanter and Co.

Culverts	£4,315	1	1
Retaining and boundary walls	6,757	16	7
Diversions of roads and approaches	4,820	3	10
Ballasting the way	17,373	15	0
Drainage of permanent way	2,788	1	10
Longitudinal and cross sleepers complete, including kyanizing, tar- ring, and fixing the same	36,964	7	9
Felt	663	5	10
Rails, screws and bolts, including laying the same and carriage	27,602	7	1
Turn-tables	2,151	1	10
Water-stations apparatus	5,668	15	2
Stations	78,736	0	6
Wharfs at Surrey Canal junction and Croydon, including ware- houses and stables	3,842	5	3
Cottages and boxes for police and switchmen, and store-house at Cold Blow	1,040	4	2
Signal and lighthouse at junction with Greenwich way, and expenses of pipes and fittings, &c. for lighting the way	1,940	19	0
Consolidation of way	11,146	18	10
Locomotive engines, carriages, and wagons	28,086	3	6
Miscellanea	18,054	17	5
	<u>£ 398,863</u>	<u>8</u>	<u>9</u>

The total cost of the railway and furnishing, however, up to the 31st July, 1840, according to the directors' last report, amounted to the enormous sum of 615,159*l.* 12*s.* 3*d.*, or at the rate of 70,239*l.* 14*s.* 7*d.* per mile!

The receipts for passengers, parcels, merchandise, &c., for one year, ending 31st July, 1840, amounted to 33,402*l.* 12*s.* 11*d.*; and the expenditure for the same period to 36,716*l.* 12*s.*, including 6,128*l.* 5*s.* 9*d.* for interest on bonds, and 5,959*l.* 13*s.* 3*d.* for toll to the Greenwich Company for the use of their line, the charge being at the rate of 3*d.* for each passenger; and when the additional double way is completed, the toll is to be raised to 4½*d.* per passenger.

This railway was laid out and executed under the direction of Mr. Gibbs; and Mr. C. H. Gregory is the Company's resident engineer at the present time.

LONDON AND GREENWICH RAILWAY.

THE advantage of selecting a convenient metropolitan terminus is fully shewn in the case of the London and Greenwich Railway. Had this line terminated, even as much as a quarter of a mile south of its present London station, the tributary lines from Brighton and Dover would assuredly have been carried to an independent London terminus. As it is, if the present Greenwich Railway is reinstated throughout, according to the plan being resorted to at Deptford, the heavy parapets removed, and iron railing introduced, as on the Blackwall line, which would increase the side-spaces each by *nine inches*, we see no reason why this should not yet become a flourishing concern. The present rattling of the trains, and the deafening noise throughout the trip, are ill suited to the improving taste of the locomotive portion of the public. The addition of a second double way for the use of the Croydon, Brighton, and South Eastern lines, will also tend much to the safety and convenience of passengers; for although it may be possible, by the greatest caution, to avoid accidents by the crossing of the line by the Croydon trains only, yet it is very improbable that if the number of trains were increased, collisions would not frequently take place. Railways crossing each other on a level should be strictly prohibited throughout the kingdom. This line is nearly level throughout.

ACTS OF PARLIAMENT, &c. — The Act for the incorporation of this Company received the royal assent on the 17th May, 1833, and empowered the Company to raise a capital in joint-stock of 400,000*l.* In 1835 a second Act was obtained, authorising the Company to raise an additional sum of 133,333*l.* The third Act received the royal assent on the 8th June, 1837, and empowered an additional capital to be raised of 150,000*l.* in 20*l.* shares, and by loan 50,000*l.* In 1840 two Acts were obtained; the one for making two additional lines as far as the Croydon junction at Corbett's Lane, and the other for the purpose of providing a station at the London terminus, to contain an area of 1·147 acres, or 50,000 superficial feet, on the level of the present railway, according to a specific plan as agreed, and to exchange the

same for the Croydon Company's London station, which contains an area of .918 acre, or 40,000 superficial feet.

The sum authorised to be raised for these purposes is 200,000*l.*; and the Croydon, Brighton, and South Eastern Companies have power to raise 150,000*l.* if necessary, for the completion of the several works.

The number of original shares is 20,000 of 20*l.* each: the number of new shares created by the Act of 1837, 7500, also of 20*l.* each; and the whole number of shares at the present time 30,770. For the purpose of raising 200,000*l.*, as authorised by one of the Acts of 1840, additional 20*l.* shares are to be created, which shall be entitled to all the profits and advantages of the shares created under the Act of 3d Will. IV. c. 46; and such shares are to be offered, in the first instance, to all the present shareholders in the proportion of one such share for every share held by each shareholder, at the price of 6*l.* 10*s.* each, to be paid by five instalments, the last of which is to be called for on the 15th October, 1841. In the event of the whole sum not being obtained by shares, 50,000*l.* is to be raised by mortgage, at 5*l.* per cent. Five per cent is the rate of interest at which the several loans have been borrowed, and which is paid in preference to all other claims. The old mortgages, amounting to 133,000*l.*, expire in 1841; and some of the more recent ones in 1845.

COURSE OF THE LINE. — Leaving the London terminus, which is immediately over Joiner Street, Southwark, and within a short distance of London Bridge, the line runs nearly parallel with Tooley Street, and to the right of St. John's Church, Horsleydown; thence crossing the Neckinger and Grange Roads, continues to the right of St. James's New Church; and slightly curving, crosses the Blue Anchor Road, Corbett's Lane, and the Surrey Canal; from whence it is produced to Deptford High Street, and thence to the station in London Street, Greenwich; the whole distance being 3½ miles.

THE VIADUCT. — The railway is formed from one end to the other on a viaduct of eight hundred and seventy-eight arches, chiefly semicircular, and of 18-feet span; but there are necessarily several skew-arches, the principal of which are over Bermondsey Street, the Grange Road, the Neckinger, and the Surrey Canal. The whole width of this structure is 26 feet, and the

clear width between parapets 22 feet; the height is about 20 feet; the arches are 18 inches; and the piers 3 feet, or four bricks in thickness. Each pier rests on a bed of concrete; the foundations of the piers vary in depth according to the nature of the subsoil, which consists, for a great proportion of the distance between London and Deptford, of a blackish peat. The ill effects of this unfavourable soil is plainly exhibited in several of the piers near the Croydon junction, which are four or five inches out of the perpendicular; and the engineer has found it necessary to introduce iron ties in other parts of the work, to prevent the brickwork from spreading laterally.* Spanning the river Ravensbourne is a balance-bridge, which requires the power of eight men to raise it, when necessary for the purpose of allowing masted vessels to pass above bridge.

On each side of the viaduct, between the Spa Road and Deptford, is a carriage and footway, enclosed by a brick fence-wall. The total width of the Company's land for this distance is about twenty-four yards.

GAUGE OF WAY, &c.—The gauge is 4 feet 8½ inches, the intermediate space 6 feet 5 inches, and each side-space only 3 feet 1 inch.

There are three kinds of rails in use on this line, viz. the old single parallel, the bridge rail, and the new double parallel. The old rail is of 50 lbs. weight to the yard lineal, is set in chairs, and secured thereto with iron keys, and fixed to cross sleepers or stone blocks, many of which latter have, however, very properly been removed. The bridge rails are laid down between Deptford and Greenwich, and fixed to longitudinal timbers in 30-foot lengths, having a scantling of 10 inches by 5 inches. Cross ties are used with the longitudinal timbers. The rails are bedded on ash planking, with a thickness of felt throughout.

* At the present time (October 1840) the permanent way, for a quarter of a mile at Deptford, is being reinstated in a most effectual manner, and the arches rendered water-tight by a thickness of concrete, averaging 9 inches above the crowns of the arches, which is overlaid with Bastenne asphalte, ½ths of an inch in thickness. A weeping-drain, covered with rubble, is built down the centre line of the way, with a fall of 7 inches in each 34-feet length. From this drain cast-iron pipes carry the water into vertical rain-water pipes of 5 inches diameter, fixed in front of the piers.

For a quarter of a mile in length, at Deptford, double parallel rails, in 16-foot lengths, are being laid down with 4-foot bearings, and weighing 78 lbs. to the yard lineal. These are set in chairs, and secured thereto by compressed wooden keys, 9 inches long and 2 inches square. The joint-chairs are 10½ inches long and 5 inches wide, and weigh each 27 lbs.; and the intermediate chairs are of the same width, but only 10 inches long, and weigh each 24 lbs. The chairs are spiked on to cross sleepers of Scotch fir, kyanized, each 9 feet long, and having a scantling of 10 inches by 5 inches, being half logs.

The ballasting consists of gravel, two feet in thickness, and extending to the whole clear width of the viaduct. Concrete, which was applied for this purpose, is all being removed.

STATIONS.—Besides the terminal stations, there is only one intermediate stopping-place, which is at Deptford High Street. This is approached by a long-sloped carriage-road on arches, and by wooden staircases for passengers arriving on foot. Under the arches of this station are situate the workshops for the repairs of the locomotive engines, &c.

As the London station is about to be materially altered, it will not be worth while to describe it in this page.

The Greenwich station is by far the most striking feature of the whole work. It is built on a magnificent scale, and with every regard to the comfort and convenience of the public. There are four lines of way under the passenger-shed, which is 63 feet 9 inches wide, 303 feet in length, and 13 feet 9 inches high. The shed is lighted by seven Venetian windows on each side. Each platform is 10 feet 9 inches wide, and is covered with patent granite. The intermediate spaces at this station are each 5 feet 5 inches; and each of the side-spaces 1 foot 9 inches wide. This shed is supported on nine segment arches, of 24 feet 9 inches and 26 feet span respectively. At the end of the shed is a semicircular recess, enclosed with a high wall, which partly supports a tank capable of holding 26,000 gallons of water, for the supply of the locomotive engines.

In this recess is fixed an apparatus, of simple contrivance, for transferring the engine and tender together from one line to the other, instead of the ordinary turn-table. It consists of two cast-iron girders, 4 feet 8½ inches

apart, and nearly 26 feet in length, which are connected together with diagonal braces. This frame is furnished with eight small wheels, or rollers, which turn on two circular plates, or tracks; two of the rollers being fixed near each extremity of the frame, and the other two about 4 feet 10 inches from the centre. The whole is enclosed within a cast-iron curb; and the frame, which turns on a centre, is easily moved with the engine and tender by one man, by the aid of a rack and pinion. This apparatus was contrived by Mr. Miller, who is at present the Company's engineer.

From the platforms of the passenger-shed passages lead to a descending staircase on each side, for those who have arrived by the train; between which an inclined platform ascends into the large second-class waiting-room, which is 60 feet in length, 30 feet in width, and 20 feet in height. It may be observed, however, that this platform is for the use of second-class passengers going by the train, who have already passed through the waiting-room. There are also waiting-rooms and conveniences for first-class passengers, for whom a separate entrance to, and staircase from, the booking-office is provided.

On the ground-floor, and underneath the waiting-rooms as above, are the entrances from London Street to the pay-office; that for the first-class passengers being in the centre of the front, and that for second-class passengers being on the right-hand side, while the exit passengers leave by a corridor on the left of this building, and which fronts the court-yard.

The pay-office is furnished with two counters of curvilinear shape, one on either side of the room, which is fitted up in the Grecian-Doric style, having columns of that order introduced to shorten the bearings of the floor above. From this office there are two passages for the second-class passengers who are going by the train, each furnished with a turnstile which registers the number passing in a given time. Between these passages is a dock, enclosed with dwarf stiles and linings, and corresponding in height with the counters. In thronged times, as at Greenwich fair, &c., policemen are placed within these docks, and are thus able to regulate the admission of these disorderly gentry.

The front of this building next London Street is in the Italian style of architecture; and is, together with the whole of the arrangements of the offices, from the design of Mr. George Smith, architect to the Mercers'

Company, under whose superintendence, and that of his partner Mr. Barnes, the whole has been executed.

The area of this station is equal to upwards of 25,000 superficial feet; and the total cost is stated to have been 27,861*l.* 10*s.*

CARRIAGES, FARES, TRAFFIC, &c. — The carriages on this railway consist of first class, in three compartments; second class, closed, in one compartment, with seats all round; and third class, open. Except about seven carriages, they are all hung low; the floor of each being within 22 inches of the level of the rails: this plan is adopted in some of the Belgian carriages. Keeping the centre of gravity as low as possible is certainly desirable for safety; besides which the annoyance of climbing up into the carriages as ordinarily hung is thereby avoided. The Greenwich carriages, however, are without buffers, the reason for omitting which we are unable to learn. The general length of carriages on this line is 14 feet 6 inches, and the width 6 feet; the weight is about 2 tons 15 cwt. The wheels are of wrought iron, and 3 feet in diameter.

The fare for a first-class passenger between London and Greenwich is 1*s.*; for a second-class passenger, 8*d.*; and for a third-class passenger, 6*d.*; which are respectively at the rates of 3·46*d.*, 2·13*d.*, and 1·60*d.* per mile. The line was opened to Deptford on the 14th December, 1837, and to Greenwich in December of the following year.

The trains start from either end of the line every quarter of an hour, from 8 A.M. to 10 P.M., except on Sundays, when the times of starting are every quarter of an hour, from 8 A.M. till 10·75 P.M., and from 1·25 P.M. to 11 P.M.

The number of passengers conveyed on this line in 1838 amounted to 1,544,266, and in 1839 to 1,513,455, shewing a decrease of about 30,800. The proportion of second to first-class passengers was as 18 to 1. Taking the two years as above, the number of passengers daily averaged 4188·65. The receipts for passengers in 1837 amounted to 38,550*l.* 16*s.*; in 1838 to 39,180*l.* 4*s.* 11*d.*; and in 1839 to 51,819*l.* 3*s.* 7*d.*

THE ESTABLISHMENT. — Besides the engineer, secretary, and clerks, there

are five collectors, twenty-two police, five porters, seven pointsmen, twelve guards, and three watchmen; there are also eleven waymen.

LOCOMOTIVE ENGINES.—The whole number of engines at present working the traffic of this line is nine; of which five are mounted on four, and the remainder on six wheels. Their proportions will be seen by reference to Table XIV. of British Locomotives, in the Appendix.

There are eight engine-drivers, and as many firemen; the former earn 40*s.*, and the latter 22*s.* a week each. There are also three coke and water-fillers, four cleaners, four fitters, one millwright, five smiths, two boiler-makers, one joiner, and four carpenters.

The coke used on this line has been reduced in cost from 40*s.* to 35*s.* per ton.

Until December, 1838, the railway was only opened to Deptford; but in 1839, the whole line being opened to Greenwich, the number of passengers fell off, but the revenue increased in consequence of the additional fare. Taking the gross receipts for passengers for the year 1839 as above, the average amount per diem on this account would be 141*l.* 19*s.* 4*88d.*

The charge for locomotive power, and the use of the carriages, is 9*d.* for the first-class passenger, 5*d.* for the second-class passenger, 3*d.* for the third-class passenger, and the toll 3*d.* for each.

The Company receive 20*l.* a year for the conveyance of the post-office bags; but have hitherto conveyed neither goods, private carriages, nor live stock.

The gross receipts for 1839 were—

For passengers	£51,819	3	7
Toll from the Croydon Company at the rate of 3 <i>d.</i> for each passenger passing over the Greenwich Railway, from the opening of that line on 5th June to the end of the year	3,522	13	9
Conveyance of post-office bags	20	0	0
	£55,361	17	4

The items of expenditure in the year 1839 were as follows:—

Locomotive power	.	.	.	.	.	.	.	.	.	£ 10,546	15	2
Coaching	.	.	.	.	.	.	.	.	.	2,828	7	1
Maintenance of way	.	.	.	.	.	.	.	.	.	4,085	3	4
Police	.	.	.	.	.	.	.	.	.	4,203	5	5
Clothing	.	.	.	.	.	.	.	.	.	160	7	0
Rates and taxes	.	.	.	.	.	.	.	.	.	3,512	13	2
Mileage-duty	.	.	.	.	.	.	.	.	.	2,348	1	7
Salaries	.	.	.	.	.	.	.	.	.	2,273	6	5
Incidental charges	.	.	.	.	.	.	.	.	.	1,124	9	4
Printing and stationery	.	.	.	.	.	.	.	.	.	334	8	0
Law charges	.	.	.	.	.	.	.	.	.	261	9	10
Brokerage	.	.	.	.	.	.	.	.	.	44	0	0
Compensation to Creek-Bridge Company	.	.	.	.	.	.	.	.	.	1,025	0	0
										£ 32,747	6	4

Thus the cost of locomotive power, maintenance of way, &c. amounted to 59·15% per cent on the gross revenue.

The original estimate for the whole work was 400,000£., and the revised estimate amounted to 533,333£. The whole cost of the undertaking, however, up to May, 1839, amounted to 640,419£., or at the rate of 170,778£. per mile, exclusive of the terminal stations: that at Greenwich is now finished and opened to the public, and is stated to have cost 27,861£. 10s.

The original survey for the Greenwich Railway was made by Mr. Giles; but the plan of carrying the railway on arches was suggested by Col. Landmann, who also superintended the erection of the viaduct and other works. The Company have at present a very efficient engineer in Mr. Miller, who is ever at his post, and has already done much towards improving this railway. The additional width from London to Corbett's Lane is to be carried into execution under the direction of Col. Landmann, the consulting engineer of the Company, who will, no doubt, take pains to produce a work worthy of the present state of British engineering.

LONDON AND SOUTH-WESTERN RAILWAY.

RAILWAY estimates have naturally caused considerable disappointment and embarrassment to a large class of shareholders. Thirteen thousand pounds per mile is the sum at which the London and Southampton Railway was estimated in the month of January, 1832. In August, 1837, it was increased to 22,167*l.* per mile; and up to the 30th June, 1840, the actual cost had been at the rate of twenty-six thousand seven hundred and eighty-eight pounds per mile, or more than double the original estimate! In the last eight years, however, engineers have acquired considerable experience as to the construction and cost of these important works: and we see no reason why every item of future estimates should not be set down with such an approach to accuracy, as shall afford the shareholders of any new line a reasonable hope of their expectations being literally fulfilled.

We have heard it frequently remarked, that if real estimates had been sent forth to capitalists, not a tithe of the present extent of railway-communication would have been effected. But we would rather attribute the cause to actual want of experience; which was certainly the case as regards the first estimate for the work under consideration. The dictum, however, of a provisional committee has, in more than one instance, been imperative; and the disfigured estimate has been sent forth as a decoy-bird to allure the unwary.

ACTS OF PARLIAMENT, &c.—The Act for the incorporation of the London and Southampton Railway Company received the royal assent on the 25th July, 1834. The capital authorised to be raised by this Act was 1,000,000*l.*, in 50*l.* shares, and an additional sum by loan of 330,000*l.* A second Act was passed in 1837, which received the royal assent on the 30th June, and empowered the Company to raise an additional capital of 400,000*l.*, and by loan 130,000*l.* In the session of 1839 a third Act was passed, enabling the Company to raise 400,000*l.* for the purpose of constructing the branch to Gosport.

The number of original shares of 50*l.* each is 20,000, and of new shares

of 25% each 16,000, the latter having the same privilege with regard to dividends as the original shares; besides which there are 6000 50%.-shares in the Gosport branch—so that the whole number of shares is 42,000.

COURSE OF THE LINE.—Leaving the station at Nine Elms, the line proceeds a little to the left of Wandsworth, and passes between Wimbledon and Merton, thence to the east of Kingston-upon-Thames, and close to Kingston-upon-Railway, which is on the right; from whence it is traced near to the following places, viz. Long Ditton, Esher, Weybridge, and Byfleet; thence, intersecting Woking Common, it is continued past Pirbright, which is on the left, and runs between Farnborough and Frimley, and thence to Winchfield, leaving Hartley Row at a little distance on the right; from which point it continues nearly in a direct line to the right of Basingstoke; and thence, curving into a direction about south by west, passes considerably to the right of Popham, and close to Mitcheldever, thence continuing to Winchester, which is on the east. From this point it is produced nearly in a direct course close to Twyford and Bishopstoke, near to which place the Portsmouth junction-line diverges. The main line continues to its southern terminus at Southampton, the whole distance being 76 miles 55·20 chains.

INCLINATIONS. — For the first ten miles from London the line alternates in inclined and level planes, the whole ascent in this distance being 58 feet; from this point it makes a slight dip, and again rises to near the seventeenth mile, where the elevation gained above the London station is 78 feet; the second dip is only for about $1\frac{1}{2}$ miles, where the height above the London terminus is 53 feet 4 inches: it now ascends to a point nearly $29\frac{1}{2}$ miles from Nine Elms; and thence, by a descent of 1 in 330, for about a mile, falls into a level plane, which continues for nearly four miles; from this point it rises gradually to $50\frac{1}{2}$ miles from London. Alternating in ascending and level planes, and thence making a slight dip of about 7 feet in two miles, it ascends to the summit, which is reached at a distance from Nine Elms of 54 miles, and at an elevation of 392 feet; from the summit the declivity is at the rate of 1 in 250, for a distance of about $16\frac{1}{2}$ miles, with the exception of a short level plane, very judiciously introduced, rather more than half way. The end of this long declivity is at a point just beyond $70\frac{1}{2}$ miles from Nine

Elms, the elevation above the London station being 45 feet 6·84 inches ; from whence the descent is continued by easy grades and the interspersions of level planes to the southern terminus, distant from Nine Elms 76 miles 55·20 chains, the difference of level between the terminal points being 1 foot 8 inches, the Southampton station being so much higher than that of Nine Elms.

In point of gradients, this line comes within the second class. The number of ascending planes between Nine Elms and Southampton is twenty-five, which amount in length to 30 miles 52 chains, and vary in inclination from 1 in 250 to 1 in 2459 ; the descending planes amount in number to seventeen, the collective length of which is 28 miles 60·80 chains, and the ratio of inclination varying from 1 in 250 to 1 in 1985. The level planes are eighteen in number, and amount in length to 17 miles 22·40 chains. The ruling and prevailing gradient is 21·12 feet, or 1 in 250. The collective length of planes thus graduated amounts to 20 miles 2·40 chains, or more than a fourth of the whole distance between Nine Elms and Southampton.

EARTHWORKS. — The earthworks throughout this line are exceedingly heavy, amounting to not fewer than 143,434 cubic yards per mile. The strata consist generally of London clay, loam, sand, gravel, and flints with chalk. The slopes vary from 1 to 1 to 2 to 1, according to the nature of the soil.

Among the principal works in this department may be mentioned the cutting at Wandsworth, extending for upwards of $1\frac{1}{2}$ miles, and averaging 28 feet in depth, its greatest depth being about 42 feet ; the Kingston cutting, $\frac{3}{4}$ of a mile in length, the greatest depth being about 42 feet, and the average depth also 28 feet ; the Weybridge cutting, 2 miles 35 chains long, and averaging 35 feet in depth ; the Frimley cutting, 1 mile 70 chains in length, and averaging 42 feet in depth ; the Odiham Road cutting, 70 chains in length, and averaging 51 feet in depth ; the Hook cutting, $1\frac{1}{2}$ miles in length, and averaging 37 feet in depth ; and the Popham Tunnel cutting, which is 96 feet 9 inches in depth.

The original estimate per cubic yard for the earthworks throughout was about *sixpence* ; the actual cost has been something like *one shilling* on an average throughout. The top width of embankments is 25 feet ; the slopes

are covered with a depth of about one foot of vegetable mould, and sown with grass seeds.

BRIDGES AND TUNNELS.—The bridges are generally built of brick throughout; the average number per mile is about two and a quarter; the span of arches over the railway is 28 feet; and their clear height above rails 16 feet; the clear width between parapets of bridges carrying the railway over roads, &c., is 25 feet. There is no particular bridge or viaduct throughout worthy of especial notice.

There are four short tunnels, besides two archways beyond Winchfield; two of the tunnels are at Popham, one at Waller's Ash, and one at Lichfield.

The Popham tunnels, which are in chalk, and separated by a deep cutting, are each 200 yards in length, 25 feet wide, and 22 feet high. Each of these tunnels was worked by two vertical shafts of about 94 feet in depth and 6 feet diameter.

The Waller's Ash tunnel, which is in flinty chalk, is 500 yards in length, and of the same cross section as those of Popham; it has two vertical shafts, each of 9 feet diameter.

The Lichfield tunnel is 200 yards in length, and is carried through chalk and flints, intermixed with small veins of clay; it is 25 feet in width, and 22 feet in height, having a semicircular arch, and side-linings of brick. A vertical shaft, of 9 feet diameter, and of 9-inch brickwork, was sunk for working it. The depth of the eastern entrance is 65 feet, and of the western entrance 58 feet. The produce of this tunnel is deposited in spoil-banks. The red bricks used in this work are of a very porous description, and were supplied from the field at Waltham, about three miles from the tunnel, at 44s. per thousand. The size of bricks made in this part of the country is $9\frac{1}{2}$ inches \times $4\frac{1}{2}$ inches \times $2\frac{1}{2}$ inches. All the tunnels are lined with brickwork throughout, of from 9 to 14 inches in thickness.

GAUGE OF WAY, &c.—The whole width of land is about 23 yards, including hedge and ditch on each side, but exclusive of slopes, which increase the width in proportion to the height of embankments or depth of cuttings. The gauge is 4 feet $8\frac{1}{2}$ inches; the intermediate space 6 feet 5 inches; and each side-space 4 feet 7 inches wide. The rails are chiefly of

the double parallel form, of 63 lbs. and 73 lbs. to the yard respectively, set in chairs, and secured thereto with compressed wooden keys. Those for the intermediate chairs are each 4 inches long, and measure in cross section $2\frac{1}{2}$ inches by $1\frac{1}{2}$ inches; and those for the joints being 6 inches long, and measuring $2\frac{1}{2}$ inches by 2 inches. The former are worth 9*l.*; and the latter 10*l.* a thousand. The chairs are spiked down to cross sleepers throughout, which are 9 feet long, and have a scantling of 10 inches by $4\frac{1}{2}$ inches. Many of the sleepers are of beech, and the whole are kyanized. The value of these sleepers is about 3*s.* 6*d.* each, exclusive of kyanizing. During the progress of the works five tanks for preparing the timbers by Kyan's process were fixed at Warren Farm, near Popham. Each tank was 30 feet long, 5 feet 6 inches deep, and 10 feet wide, and of sufficient capacity for 300 sleepers at one time. The sleepers remained in the solution for six or seven days together. Six men were constantly engaged at this operation. Transverse gullies are formed from the middle of each way to carry off the water into the side-drains, as in the Birmingham, and other principal lines, where cross sleepers are used.

The ballasting is chiefly of gravel. The fencing consists of posts with three, and in some parts of the line four rails. The side-drains are chiefly open throughout the works.

STATIONS.—Besides the London and Southampton stations, there are twelve intermediate stopping-places, viz. Wandsworth, which is 3 miles distant from Nine Elms; Wimbledon, 6 miles; Kingston, 10; Esher, 13; Walton, $15\frac{1}{2}$; Weybridge, $17\frac{1}{2}$; Woking, 23; Farnborough, $31\frac{1}{2}$; Winchfield, 38; Basingstoke, 46; Andover Road, 56; and Winchester, 64.

The station and dépôt at Nine Elms are rather on an extensive scale, occupying together about seven acres. The warehouses are close to the river, and are approached by a siding produced from the main line, and crossing the Nine Elms road on a level.

The offices, which front the Nine Elms road, present a neat elevation, from the design of Mr. Tite, architect to the Company. The entrance to the booking-office is in the middle of this front, under an arcade which extends along the principal part of its length. On the left of the booking-office are separate waiting-rooms for ladies and gentlemen; and on

the right a private office. The passenger-shed is immediately in the rear of the offices, and is approached by a door from the booking-office. On the first floor are the secretary's offices, the board-room, accountant's office, and Mr. Reed's private apartments. There is also a third floor, in which are the audit-office, and other rooms appropriated to Mr. Reed.

The passenger-shed extends from the offices for a length of 290 feet, and is altogether 74 feet 9 inches in width, and 17 feet 3 inches high. The departure-platform is 13 feet 6 inches, and the arrival-platform 15 feet 9 inches wide, and are each covered with asphalte; the top surface of each platform is 15 inches above the level of the rails. The queen-post wooden roof extends over the railway only, and is supported by two lines of light iron columns 12 feet in height, and ornamental iron ribs extending from column to column for the whole length. The platforms are covered with flat roofs; that on the departure-side being supported by a 14-inch wall, and one line of columns; and the arrival-platform by two lines of columns. The departure-side would be better for the introduction of sky-lights above, or windows in the side-wall. There are four lines of way under this shed; the intermediate spaces are each 6 feet 10 inches; and the side-spaces 2 feet 6 inches wide. Near the end of the shed a transverse line, with four turn-tables at the points of intersection, runs across to the carriage-landing, which is on the right as you leave Nine Elms,—an arrangement somewhat similar to that of the Euston station of the Birmingham line. Without the shed a second cross line runs off to the carriage-house and locomotives' department. There are altogether beyond the shed eleven lines of way, including sidings.

The departure-gates for common-road vehicles and for foot-passengers, which are in a line with the front of the offices, are on the same side as the arrival-platform.

The locomotives' engine-house is a rectangular building, lofty and convenient, and is furnished with four lines of way, some of which are provided with engine-races; benches are placed next the walls. The entrance is closed when required by large sliding-doors. A triple way is extended from the Nine Elms station as far as the coke-ovens.

COKE ESTABLISHMENT.—The coke-ovens, which were erected by Mr. Prior, are situate about a quarter of a mile from the Nine Elms station, and on the

right side of the line; it is sunk about 10 feet 6 inches below the railway, which is here supported by a retaining wall, averaging about two bricks in thickness. The ovens are sixteen in number, and each of ten feet clear diameter, ten of which are ranged in a line at right angles to the railway, and the remaining six run across the floor; the whole forming a figure similar to the letter T. In front of the chief line of ovens a shed, covered with corrugated roofing, and supported on light iron columns, extends for their whole length. The cooling-floor, which is under the roof, is paved with brick. The ovens are built of common stocks, and lined inside with fire-bricks. Each oven is bound with four iron girdles, 5 inches wide and $\frac{1}{4}$ -inch thick, which are secured to a cast-iron mouthpiece. The flues, which are built of fire-bricks and Stourbridge clay, are 2 feet 3 inches wide and 3 feet high, and run over the ovens to the chimney, being supported by segmental arches throughout, which are built in two rings; the flues are covered with saddle-bricks from Stourbridge. The pedestal on which the chimney stands is placed behind and in the middle of the longest line of ovens; it is 12 feet 9 inches square and 16 feet high; the lower external diameter of the chimney is 12 feet 9 inches; each oven-door is suspended by a chain running over pulleys, and its ascent and descent are regulated by a counter-weight attached to the other end. The foul air is emitted by a small aperture in the back of the oven. The charge for each oven is nearly equal to four tons of coal, which is of the description known as Tanfield Moor. While one man is wheeling the coals from the heap to the front of the oven, another man is charging it. Eight ovens are drawn daily. This operation is performed about five o'clock in the morning. The process of coking occupies forty-eight hours. The operation of charging commences one hour after drawing the ovens, which are sufficiently hot to ignite the new charge of coal. As the coke is drawn from the oven, it is placed in heaps on the floor, and cooled with water. There are altogether for this purpose five tanks, each 4 feet square and 4 feet deep. The cooling occupies about two hours. Twenty and a quarter tons of coke are produced from thirty tons of coal.

The persons employed at this establishment are eight burners and eight labourers, besides the foreman. The burners earn each 29s., and the labourers 16s. per week. The coke is conveyed from this station in wagons built for the purpose, with sides formed of wooden rails, and vertical standards.

A wagon will hold sixty sacks of coke, each weighing 112 lbs. Every sack is weighed before being put into the wagons; and a ticket, with the weight, &c., is delivered to the person fetching it, who is required to sign it, a duplicate being kept by the foreman of the coke-ovens.

An intermediate station on this line consists generally of a cottage-building, containing a booking-office and general waiting-room, with proper conveniences; and, in some instances, as at Esher, living-rooms for the station-clerk and porters, or policemen. At the principal intermediate stations there is a separate waiting-room for ladies. On the up-side there is usually a waiting-shed, set back at some distance from the front of the platform. At Woking, Basingstoke, and the principal intermediate stations, there is a water-column at each end and on opposite sides of the line; one for the supply of the down, and the other for the supply of the up-trains.

CARRIAGES AND LOCOMOTIVE ENGINES. — The carriages consist of first and second class, of nearly the same size and weight as those of the London and Birmingham Railway. The first class are in three compartments, each of which will hold six persons, or eighteen in all; and the second class also in three compartments, each of which will hold eight persons, or twenty-four in all.

The locomotive engines are chiefly mounted on six wheels: their proportions will be found in Table XV. of British Locomotives, in the Appendix.

We found the average weight of eleven passenger-trains on this line to amount to 84,321·45 lbs.; the average velocity to be at the rate of 23·14 miles per hour; the highest velocity 50 miles per hour; and the stoppages to occupy, on an average, 2·09 minutes each. (See Table L. of Results of Practical Experiments, in the Appendix.)

FARES, TRAFFIC, &c. — The fares for passengers by the first-class trains, which perform the journey from London to Southampton in three hours, are at the rate of 3·129*d.* per mile, and by the mixed trains 2·816*d.*; and for second-class passengers by the mixed trains the fare is at the rate of 1·877*d.* per mile.

The number of passengers conveyed on this line from June, 1838, to December, 1839, both inclusive, amounted to 733,364½, or at the average rate of 1266·60 per diem.

The line was first opened to Woking Common on the 21st May, 1838; and on the 21st September following it was further opened to Winchfield. On the 1st May, 1839, it was opened as far as Basingstoke; and on the same day, that portion of the line between Winchester and Southampton was also opened to the public, the intermediate distance being performed by common-road stages; the opening throughout took place on the 11th May, 1840.

The following exhibits an account of the expenditure from the commencement of the undertaking up to the 30th June, 1840 :—

Acts of Parliament, and expenses incurred in raising the capital, &c.	£ 41,467	2	0
Land and compensation, conveyancing, surveying, and valuing .	291,200	2	5
Earthworks, bridges, culverts, stations, fencing, drainage, &c. .	1,114,605	5	2
Rails, chairs, and sleepers	340,006	0	7
Engines and carriages	140,325	16	0
Wagons, implements, tools, and stores	59,566	4	4
Engineering and surveying	33,448	19	6
Salaries and wages, rent and taxes, printing and stationery, } postage, travelling, and other incidental expenses . . . }	24,729	3	7
Direction	5,350	0	0
Debenture-bonds, stamps, and brokerage	3,687	11	10
Total for main line	£ 2,054,386	5	5

The expenditure on account of the Gosport branch up to 30th June, 1840, amounted to 86,643*l.* 7*s.* 10*d.* The gross receipts, up to the same date, amounted to 2,150,609*l.* 9*s.* 7*d.*, including 630,100*l.* on debenture-bonds, 140,940*l.* on calls for Gosport branch, and 3,513*l.* 9*s.* 7*d.* for interest.

The receipts for traffic, &c. from the first opening of the railway to Woking Common, on the 21st May, 1838, to the 30th June, 1840, amounted to 278,150*l.* 14*s.* 4*d.*

The expenditure in working the line for the same period was as follows :—

Locomotive power, including repairs of engines, coke, wages, &c.	£ 62,052	9	6
Coaching and carrying, including mileage-duty, wages, repairs of } carriages, &c. }	45,632	0	2
Maintenance of way	34,539	4	5
Police	6,175	17	0
	£ 148,399	11	1

But to this amount should be added the following, viz. direction, 2531*l.* 10*s.* 1½*d.*; interest on debenture-bonds, 25,182*l.* 3*s.* 10*d.*; and also the item of salaries, rent, taxes, office-expenses, &c. Thus the annual cost since opening the line, exclusive of salaries, &c., has been at the rate of 83,505*l.* 11*s.* 5*d.*, or 63·31*l.* per cent on the gross revenue.

The Southampton Railway was originally surveyed by Mr. Giles, and the works were partly executed under his direction; but the whole has been finished under the general direction of Mr. Locke, who is engineer to the Company at the present time.

MANCHESTER AND BIRMINGHAM RAILWAY.

THE Manchester and Birmingham, or, more properly, the Manchester and Crewe Railway, arose out of two distinct projects which were before Parliament in the session of 1837: the one called the Manchester South Union, which was to run from Manchester to the Birmingham and Derby Railway at Tamworth, a distance of 71 miles 46 chains; and the other the Manchester, Cheshire, and Staffordshire Railway, the main line of which was to form a communication between Manchester and the Grand Junction Railway near Stafford, a distance of 50 miles 71 chains. Mr. Stephenson was engineer to the former, whose estimate for the whole, including branches, extending altogether 97 miles 38·50 chains, was 2,000,000*l.*, or at the rate of about 20,544*l.* per mile; and Mr. Rastrick to the latter, which, including branches, was altogether 92 miles 11 chains in length, the estimate for the whole being only 1,560,000*l.*, or about 16,931*l.* per mile! It may be as well to state briefly some of the principal engineering features of each scheme.

In the South Union Railway, the tunnelling amounted to 748 yards in length; the principal viaducts were that at Manchester, 1386 yards in length and about 20 feet high; the river Dane viaduct, 440 yards long and about 110 feet high; and the Stockport viaduct, 80 feet high. The number of bridges was 464, or 4·77 per mile. The cuttings, with an average depth

varying from 26 feet to 55 feet, amounted in length to 8 miles 64 chains; and the ruling gradient was 20 feet, or 1 in 264; while the length of tunnelling on the Manchester, Cheshire, and Staffordshire line, amounted to 2310 yards: the principal viaducts were that over the river Medlock; the Mersey viaduct, 103 feet high; that over the river Dane, 116 feet high; and two over the Trent, 35 and 42 feet in height respectively. The cuttings, with an average depth of from 20 feet to 32 feet, amounted in length to 8 miles 19 chains. The number of bridges was 396, or at the rate of 4·29 per mile; the ruling gradient on the main line being 14 feet, or 1 in 377, and on the Shelton and Madeley branch 53·33, or 1 in 99.

The result of this parliamentary contest was the appointment by Government of a military engineer to examine the country and report on both lines; and an amalgamation of interests was in consequence agreed upon, the Manchester, Cheshire, and Staffordshire Railway being made up of parts of each line, a portion of which was to be executed under the direction of Mr. Stephenson, and the remainder under that of Mr. Rastrick.

It is proper to observe, however, that the Manchester and Cheshire line was before Parliament in 1836, and opposed by the promoters of the intended South Union scheme; and it is rather a curious circumstance, that the present Manchester and Birmingham Railway has the same termini as the original Manchester and Cheshire Railway, although it pursues a different course.

ACTS OF PARLIAMENT, &c.—The Act of incorporation received the royal assent on the 30th June, 1837, and authorised the Company to raise a capital in joint stock of 2,100,000*l.* in 30,000 shares of 70*l.* each, and by loan 700,000*l.*, making together 2,800,000*l.* An amended Act was obtained in the session of 1839, for the purpose of altering the course of the intended line by Congleton to the Potteries; but, after all, this important part of the undertaking has been abandoned, and the Crewe branch made part of the main line.

COURSE OF THE RAILWAY.—Leaving the station in Store Street, Manchester, the main line is produced by an easy curve as far as its crossing of the Hyde Road; from whence it continues nearly south, and in a direct line to Stockport. Leaving this place, the line is continued by Castle Street, and crossing Mecker Brook by seven 30-foot arches, passes near Cheadle and

Wilmslow, and through Sandbach parish, to its termination at Crewe, where it joins the Grand Junction Railway, at a distance from Manchester of about $29\frac{1}{2}$ miles.

The Macclesfield branch leaves the main line in the township of Cheadle Bulkeley, and proceeds through the townships of Adlington and Titherington, to its eastern termination near Macclesfield, a distance of 11 miles.

The inclinations of that part of the line already opened between Manchester and Stockport, taken in order, are 1 in 377, 1 in 480, 1 in 587, and 1 in 377, all ascending towards Stockport; the Manchester plane, and that at Stockport, being level. The whole length between these stations is about $5\frac{1}{2}$ miles.

EARTHWORKS, BRIDGES, &c.—In that part of the line which is completed between Manchester and Stockport, the earthworks consist of an embankment extending from the end of the Manchester viaduct to the Heaton Norris cutting; the Heaton Norris cutting; and a second embankment, which reaches to the north end of the Stockport viaduct. The sand used for ballasting the permanent way was led from the Heaton Norris cutting.

The Manchester viaduct extends from the Manchester station in Store Street to the crossing of the Hyde Road, the chief part of which is built of brickwork, with stone springers and copings. The arches vary considerably in span. On the south side of Fairfield Street, they are altogether built in rings, and of segmental form, having a span of 33 feet 6 inches, with a versed sine of 10 feet 6 inches, their thickness being equal to $3\frac{1}{2}$ bricks. The height from the level of the ground to the springing-line of arches is 18 feet, and the whole height to top of parapet 38 feet; the extreme width of the viaduct is 31 feet, and the clear width between the parapets $28\frac{1}{2}$ feet.

Besides the regular arches, there are several built askew, the principal of which is that over Fairfield Street. It consists of six cast-iron segmental ribs, each of which extends 129 feet 7 inches, having a versed sine of 12 feet; the whole height of this arch above the level of Fairfield Street being 23 feet. The abutments are built of masonry, and being formed in horizontal steps, or jumps, the ribs take a rectangular bearing at each end, and are connected together with diagonal ties. The arc of each front rib is divided into nine panels, the depth of the arc at the abutment being 4 feet, and

at the crown 3 feet. The ribs are severally fixed in cast-iron abutment-sockets. The square span is 53 feet 4·68 inches, and the angle of obliquity $24\frac{1}{2}^{\circ}$: the whole weight of iron in this arch is about 540 tons. The water is drained from the viaduct by 4-inch rain-water pipes, which are carried down from cesspools in the middle of the permanent way, and run out at the sides of the piers at a height above the ground of $4\frac{1}{2}$ feet.

Between the south end of the Manchester viaduct and that of Stockport there are four road-bridges over the railway, including one of three arches; two occupation-bridges over; three bridges under the railway, including one of three arches; and eight occupation-arches under.

The span of bridges over the railway is 30 feet, and their clear height above the level of rails 16 feet. The clear width between parapets of bridges carrying the railway over roads, &c. is $28\frac{1}{2}$ feet, and the thickness of parapets 14 inches.

STOCKPORT VIADUCT.—This structure presents one of the most imposing works of the kind in the kingdom, whether viewed as to its general design or exquisite workmanship. It is in the highest degree interesting to the civil engineer; and will long remain a monument of the skill of him who designed it, and of the energy and perseverance of those who were entrusted with its execution, and have so successfully brought it to completion. But we must not omit in this page to record the name of the engineer—it is George Watson Buck, formerly of the London and Birmingham Railway, and who has distinguished himself by his intimate acquaintance with bridge-building, and particularly with the more difficult branch which embraces oblique arches, whether of brick, iron, or stone. Nor should we be doing justice to the contractors, Messrs. Tomkins and Holmes, of Liverpool, were we to leave their names unnoticed here.

This viaduct, which carries the railway over the river Mersey, at Stockport, at an elevation of 106 feet above the water's surface, consists of twenty-two semicircular arches, each of 63-feet span and 3 feet in thickness, which, as well as the spandrels, are built of red brick. The piers, which are of stone as high as the springing-line of arches, are each 9 feet 9 inches in thickness, and their average height is about 40 feet: they are built solid to a height of 26 feet above the springing, and the space above is filled with ballast.

Besides the main arches, there are two abutment-arches at either end, each of 18 feet span. The height from the crown-line of the arches to the top of the parapet is 11 feet 9 inches; and the height of the parapet 7 feet 3 inches.

The whole length of this structure is 2179 feet, and the extreme width 31 feet; the clear width between the parapets is 28 feet 6 inches. The rain-water is conveyed from the permanent way by iron pipes, as mentioned in the description of the Manchester viaduct.

GAUGE, RAILS, &c.—The gauge of way is 4 feet 9 inches, in order to allow of sufficient play for the wheels of the locomotives and carriages to the extent of a quarter of an inch on each side. The intermediate space is 6 feet $5\frac{1}{2}$ inches; and each side-space 6 feet 6 inches wide.

The rails are in 15-foot lengths, and of the single parallel form, weighing 65 lbs. to the yard lineal; their depth is 5 inches, the extreme width of top web $2\frac{3}{4}$ inches, the depth of same $1\frac{1}{4}$ inches, and the thickness of the stem 1 inch. The rails were supplied from the Chillington Works, near Wolverhampton; from the Dowlais Works, South Wales; and from Gold's Hill, West Bromwich.

Stone blocks from Rayner Quarry, near Congleton, are used in the cuttings, each containing 4 cubic feet. The plug-holes, which range diagonally, are two in number, each of $1\frac{1}{2}$ inches diameter, and $8\frac{1}{2}$ inches apart. The sleepers are 9 feet in length, and of about the usual substance.

The ballasting is of sand, which is laid one foot below the bed-line of blocks. Besides the open-field drains, circular perforated earthen drains are used to great extent in the cuttings. They are each 2 feet 5 inches long, 14 inches in extreme diameter, and $12\frac{1}{2}$ inches in the clear. They are formed as iron water-pipes, with spigot and faucet; the clear diameter of the faucet, or larger end, being $14\frac{1}{2}$ inches, and the whole depth of the neck 4 inches. (See Plate 16.)

The fencing consists of hedge and ditch, with stout posts and four rails. The posts are each 6 inches by 4 inches, and 9 feet from middle to middle; each post is iron-bound at top. The rails are each $4\frac{1}{2}$ inches by $2\frac{1}{2}$ inches, and are cut diagonally at the meetings; a vertical upright stay, 3 inches by $1\frac{1}{2}$ inches, is fixed to the rails midway between each pair of posts. At the tops of cuttings the wooden fencing is placed at a distance of 7 feet from the

verge of slope. The whole width of land enclosed, exclusive of slopes, is 19 yards.

LOCOMOTIVE ENGINES AND CARRIAGES, &c.—Six-wheel engines, from the works of Messrs. Rt. Stephenson and Co. of Newcastle, and Messrs. Sharp, Roberts, and Co. of Manchester, are used on this line.

The carriages consist of first, second, and third class. The fare for a first-class passenger between Manchester and Stockport, a distance of $5\frac{1}{4}$ miles, is 12*d.*, or at the rate of 2·304*d.* per mile; for a second-class passenger 9*d.*, or at the rate of 1·714*d.* per mile; and for a third-class passenger, 6*d.*, or at the rate of 1·142*d.* per mile.

There is only one intermediate station, which is at Rushford, where the trains stop, if required, to take up or set down passengers.

The line between Manchester and Stockport was opened for public accommodation on the 4th June, 1840. The number of persons conveyed by the trains in the twenty weeks ending October 19th, amounted to 268,316, or, on an average, about 1920 per diem. The receipts for the same period amounted to 7377*l.* 7*s.* 4*d.*, or 52*l.* 13*s.* 9½*d.*, on an average, per diem.

Up to 31st July, 1840, the total receipts amounted to 842,467*l.* 14*s.* 11*d.*, and the expenditure to the same date to 895,914*l.* 11*s.* 5*d.*

MANCHESTER AND BOLTON RAILWAY.

A FEW years ago a communication by canal existed between the metropolis and Croydon. The canal, however, has been drained, and the Croydon Railway now occupies the general site of the many-locked navigation. As was the case with the Croydon Railway Company, so the original intention of the promoters of the Manchester and Bolton line was to have converted the canal from Manchester to Bolton and Bury into a railway, altering the line where the sinuosities were unfavourable, but taking the general course

of the water-communication. This Company had agreed for the purchase of the canal, at a sum exceeding 100,000*l.*, which agreement was afterwards confirmed by their Act of incorporation. By a subsequent Act of Parliament, however, the powers of annihilating the canal were repealed; and the Company was enabled to retain the canal, and to make a railway also.

ACTS OF PARLIAMENT, &c.—The Act for the incorporation of this Company received the royal assent on the 23d August, 1831, and authorised a capital in joint-stock to be raised of 204,000*l.* A second Act was obtained on the 1st June, 1832, empowering the Company to raise by loan 46,000*l.* On the 17th June, 1835, the royal assent was given to a third Act, authorising the capital in joint-stock to be augmented by a sum of 250,000*l.*; and on the 11th June, 1838, a fourth Act was obtained, giving the Company power to raise by loan an additional sum of 150,000*l.*

The number of shares is 6,201, each of 125*l.* 9*s.* 8*d.* Up to June, 1839, the amount raised by calls was 473,356*l.*; and by bonds and mortgages, 253,469*l.*; and there yet remained to be raised 51,291*l.*; making the capital of the Company 778,116*l.*

COURSE OF THE LINE.—Leaving the station in New Bailey Street, Salford, by a viaduct of several arches, the line passes under the Oldfield Road, at a distance from the Liverpool and Manchester Railway of 325 yards; thence running parallel to the canal, which is here on a curve of about 12 chains radius, continues to Pandleton, and to the north-east of Clifton; thence to Stone Clough, and is produced to its termination at Bolton; the whole distance being ten miles.

INCLINATIONS.—Commencing at the station in New Bailey Street, Salford, the line runs on a level for 10 chains; thence descends as far as the Oldfield Road bridge, a distance of 26 chains, at the rate of 1 in 1312. The next plane ascends, at the rate of 1 in 160, for 28 chains; thence follows a second level plane, which is 16 chains in length, from which point the whole line ascends towards Bolton by four planes, the lengths and inclinations of which are respectively as follows: 52 chains, 1 in 1034; 1 mile 33 chains, 1 in 544; 4 miles 61 chains, 1 in 200; and 1 mile 67 chains, 1 in 274½; the Bolton

terminal plane being level, and 27 chains in length. The worst inclinations are 1 in 160 for 28 chains, and 1 in 200 for 4 miles 61 chains. Thus, in point of gradients, this line comes under the second class. The summit of the line is at Bolton, which is 239 feet 11·28 inches above the level of the rails at the Manchester station.

EARTHWORKS, BRIDGES, &c.—The country intersected by this railway is of a very rugged description; the earthworks, in consequence, are exceedingly heavy throughout. Dwarf retaining-walls have been introduced in many of the cuttings, for the purpose of decreasing the area of land, and the quantity of material to be excavated. The slopes are generally sown with clover-seed. There is only one tunnel, which is 300 yards in length, and was substituted during the progress of the works for an open cutting, as originally intended.

The bridges are altogether thirty-three in number; twenty-four of which are over the railway. Some of the bridges over the railway are altogether smaller than those of any other public double line in the kingdom. In order to get sufficient head-way for the passage of the locomotive engines, Mr. Hartley, the engineer under whose direction this line was constructed, “has separated the two lines of way by iron columns, thus shortening the bearings, and enabling him to give the least practicable depth to the cast-iron road-bearers.”* The side-spaces, however, are inconveniently narrow, and indeed very dangerous; for a person stretching his head a little too far beyond the side of the carriage, while passing under one of these bridges, would be pretty certain to have it decapitated. The masonry has an appearance of solidity throughout.

GAUGE OF WAY, &c.—There is a double way throughout, with additional lines at the terminal stations. The gauge of way is 4 feet 8½ inches, and the intermediate space 5 feet in width.

The rails used are of the broad-based parallel form, and somewhat similar to those of the Croydon and North Shields Railways (see Plate III. fig. 44, and also figs. 40 and 50), and their weight per lineal yard is 55 lbs. The

* Whishaw's “Analysis of Railways,” page 269.

rails are fixed to cast-iron pedestals, 14 inches long, 6 inches wide, and $1\frac{1}{2}$ inches thick, having a slight sinking in the direction of their length, in which the rails are bedded. These pedestals are, in some parts of the line, secured to continuous longitudinal stone sleepers; and in other parts to kyanized half baulks, which are cut a little diagonally, as those last introduced on the Great Western Railway (see Plate 16). Cross sleepers are introduced beneath the longitudinal timbers, as on the Croydon Railway. Each pedestal has six perforations of $\frac{1}{4}$ of an inch diameter, and is secured to the stone by two screw-bolts. The rails are secured to the pedestals by four screw-bolts, driven through the perforations into the stone, and having sexagonal nuts, which clip the base of the rail on its upper surface. Mr. Hawkshaw's patent slide-rails are introduced on this line, and appear to answer their purpose exceedingly well.

The drainage has had considerable attention paid to it throughout the line. In the cuttings many of the lateral drains are formed of stone, some of which are covered with flags, and all appear to be of full section to receive the surface-water from the slopes. The fencing is not so complete: in some parts there are only two rails, and in others three. The mile-standards are placed at intervals of a quarter of a mile each.

CARRIAGES. — The coaches for the conveyance of passengers on this line consist of first and second class. The first class are each in three compartments, are mounted on four wheels, and will each hold eighteen passengers. The cost of a first-class carriage is 480*l.* complete; and its weight is equal to 76 cwt. Some of these carriages were built by Mr. Cooper, of Bradshaw Gate, Bolton. A second-class carriage is somewhat similar to those in use on the Greenwich Railway, having no division, but seats all round and down the middle, with a door on each side. It is roofed over, but enclosed at one end only, the sides and other end being open. The journey, however, is but of short duration, or we should certainly recommend the directors to study a little more the comfort of their second-class passengers. The length of a second-class carriage, which is calculated to hold thirty-two passengers, is 14 feet, the width 6 feet 4 inches, and the height 5 feet 6 inches; the roof is supported by vertical iron standards. The cost of this kind of conveyance is stated by Mr. Ritson to be 100*l.*

The goods-trucks are of about the usual weight, and the cost of each 50*l*.

STATIONS. — The offices of the Manchester station front New Bailey Street, and present a neat elevation, with three entrances, the central one being to the booking-office, the right hand to the treasurer's, and the left hand to the engineer's offices. The whole length of this building is 78 feet, and the depth 30 feet. From the passage in front of the booking-office a flight of stairs leads up to the arrival and departure platforms. The egress for arrival-passengers is by distinct staircases, which lead out into the street under the end arches of the viaduct. The platforms are arranged on either side of the railway, and are continued at the end next the offices. There are altogether five lines of way at this station; the whole, except the front offices, being raised on a viaduct, which extends for a considerable distance beyond the station.

At the Bolton terminus the offices are likewise placed across the end of the railway, but are nearly on the level of the rails; and the approach from the street to the booking-office is by a descending flight of steps. There are five lines of way at this station, terminating in as many turn-tables. Three of the lines are covered by a queen-post wooden roof, supported on iron columns. This roof projects over one of the passenger-platforms; and on the other side of the double main way, the platform, which is 11 feet wide, and 15 inches above the rails, is enclosed behind with a brick wall; and the whole is covered in with a sloping roof, the front of which is supported on iron columns.

The goods-depôt, on rather a large scale, is contiguous to this station.

Besides the terminal stations, there are several intermediate stopping-places, the principal of which is at Stone Clough; but the Company have very wisely abstained from throwing away money by the erection of costly buildings.

TRAFFIC, FARES, &c. — This line was opened to the public on the 29th May, 1838. The number of persons conveyed by the trains from the 1st June following to the end of the year 1839 was 508,481, or on an average at the rate of 878 per diem. The receipts for passengers, parcels, &c., from June 1838 to April 1839, both inclusive, amounted to

19,887*l.* 12*s.* 8*d.*, or at the rate of 59*l.* 10*s.* 10½*d.* on an average per diem ; and from May to December 1839, both inclusive, the revenue from passengers only amounted to 14,164*l.* 10*s.*, or at the rate on an average of 57*l.* 16*s.* 3·44*d.* per diem.

This Company is authorised by their Act of incorporation to charge for every passenger in open wagons at the rate of 2½*d.* per mile ; and also 2½*d.* per mile in covered carriages, with such reasonable sum in addition as they might from time to time determine.

From the 29th May to 10th June, 1838, the first-class fare was 2*s.* 6*d.* for the whole distance of ten miles, or at the rate of 3*d.* per mile ; and the second-class fare was 2*s.*, or at the rate of 2·40*d.* per mile.

Third-class carriages were introduced on the 11th June, 1838, but were discontinued on the 1st of December following, in consequence of the Company finding the numbers fall off considerably by the first and second-class conveyances.

From the 11th June to 30th November, inclusive, the fares were 2*s.*, 1*s.* 6*d.*, and 1*s.*, or at the respective rates of 2·40*d.*, 1·80*d.*, and 1·20*d.* per mile ; and from the 1st December, 1838, to the present time the first-class fares have remained at 2*s.* 6*d.*, and the second-class fares at 1*s.* 6*d.*, for the whole distance ; or at the rates of 3*d.* and 1·80*d.* per mile respectively.

It is the custom of this Company to carry goods with their passenger-trains ; but they have not hitherto conveyed private carriages, horses, or live stock of any description.

The maximum charge for the conveyance of goods is at the rate 4·02*d.* ; and the minimum 3*d.* per ton per mile respectively.

The passengers' tickets are taken before arriving at the journey's end.

LOCOMOTIVE ENGINES.—The engines used on this line are ten in number ; each engine is mounted on four wheels, and according to Mr. Bury's plan (see Plate VI.) : their proportions will be seen by reference to Table XVI. of British Locomotives, in the Appendix.

The number of trains daily in each direction is ten, except on Sundays, when it is reduced to two : the distance, therefore, run by the Company's engines in a year is equal to 64,680 miles, or on an average at the rate of 6,468 miles for each engine.

The consumption of coke, which Mr. Hawkshaw considers equal to that of Worsley, is about 720 tons per annum; the cost, at 21s. a ton, being equal to 756*l.* per annum.

The original estimate for this railway was 300,000*l.*; the actual cost has exceeded 600,000*l.*, or at the rate of 60,000*l.* per mile. The land was estimated at nearly 50,000*l.*; it has cost double. The stock of engines is estimated at 12,000*l.*, or at the rate of 1200*l.* per mile. The maintenance of way is stated to have cost at the rate of 214*l.* per mile per annum, or 2140*l.* for the whole line. The interest on mortgages and loans amounts to 12,000*l.* a year.

The gross revenue per annum for passengers, &c. by the railway amounts to about 22,700*l.*; from which, in order to obtain the amount of profit from this source, should be deducted the expenses in the locomotive and carrying departments, the maintenance of way, the interest on mortgages, the office-expenses, and salaries, &c.; but we are not in possession of the amount of these several items. The net profits of the canal were stated by Mr. Hawkshaw, at the last general meeting of the proprietors, to amount to 8000*l.* per annum.

There is every reason to expect that when the line from Bolton to Preston, which is a continuation of this line northward, is opened to the public, it will materially increase the revenue of the Manchester and Bolton Railway Company; and it is very desirable that the proposed junction with the Liverpool and Manchester Railway at Cross Lane, and the extension to the Manchester and Leeds Railway at Hunt's Bank, should speedily be carried into execution.

MANCHESTER AND LEEDS RAILWAY.

If the population of a district through which a railway is carried afford any adequate notion of the extent of traffic that may be expected upon its entire opening, then may the proprietary of the Manchester and Leeds Railway look forward, almost with certainty, to an ample return for their outlay,

notwithstanding the enormously increased expenditure above the original estimate. According to the census of 1831, the population within three miles on either side of the line amounted to about 664,920 souls, or about 1847 per square mile; whereas the average population throughout the whole of England was found to be at the rate of only 260 individuals per square mile.*

Our opinion, already expressed in another work,† as to the importance of the Manchester and Leeds Railway, remains unaltered. We consider it one of the principal lines of railway throughout the kingdom, forming, as it does, the main link in the great transverse chain between Liverpool and Hull.

The manufactures of cotton, woollen, worsted, silk, and linen, are carried on to an amazing extent in the district traversed by this railway. Cotton, which is chiefly imported to Liverpool in its raw state, is sent from thence to the different factories to undergo the necessary course of preparation, from whence it is conveyed to Manchester either for home sale or for exportation.

A great proportion of the cotton manufactured in Great Britain, and intended for continental markets, is sent from Manchester to the ports of Hull and Goole; and the woollens and worsteds manufactured in the West Riding of Yorkshire are, to a great extent, transmitted to Liverpool to be exported to the East and West Indies, to Canada and the United States, to South America, and to other parts of the globe.

We need, however, dwell no longer on the importance of this line to the particular district through which it passes. It must, it will, confer incalculable benefits, not only on the particular districts, but also on the community at large.

In an engineering point of view, it is equally important; and if completed throughout, in the way in which those parts already opened to the public afford so many excellent specimens, it will redound to the credit of GEORGE STEPHENSON more than all his other works put together. The line is literally studded with engineering difficulties from end to end, and those of no ordinary magnitude.

* This fact was prominently noticed in the Prospectus of the Manchester and Leeds Railway Company, dated 1st February, 1836.

† Whishaw's "Analysis of Railways." 2d edition, p. 163. Weale, High Holborn.

It must be a source of high gratification to those who, under Mr. Stephenson, have been engaged in carrying out this great work, to think that the formidable difficulties which beset their path at almost every turn are so nearly surmounted; and we must not omit to record in this page the name of the fortunate individual who has had the immediate superintendence of this stupendous work. It is Thomas Longridge Gooch, a pupil of the engineer-in-chief, and who had acquired considerable experience on the London and Birmingham Railway.

ACTS OF PARLIAMENT, &c. — The Act for the incorporation of the Manchester and Leeds Railway Company received the royal assent on the 4th July, 1836, and authorised a capital to be raised in joint-stock of 1,300,000*l.*, and by loan 433,000*l.* additional. A second Act was passed in 1839, which received the royal assent on the 1st July of that year, authorising the sum of 866,000*l.* to be raised for the purpose of constructing the Oldham and Halifax branches, for making a diversion in the railway at Kirkthorpe, for enlarging the present station in Lees Street, and for constructing the line to Hunt's Bank, to join the Liverpool and Manchester proposed extension. The whole amount thus authorised to be raised is 2,599,000*l.*

The number of original shares is 13,000 of 100*l.* each, and of new shares also 13,000 of 50*l.* each, making the joint-stock capital equal to 1,950,000*l.*

The total amount received up to the 30th June, 1840, on account of calls, mortgages, bonds, &c. was 2,116,519*l.* 15*s.* 3*d.*; and the total expenditure to the same date was 2,113,988*l.* 15*s.* 7*d.*

GENERAL COURSE OF THE LINE.—Leaving the present station at Lees Street, Manchester, on the north side of the Oldham road, the line runs in a north-eastern direction towards Rochdale, passing in its course to the east of Middleton; from Rochdale it is continued to Littleborough, which is on the west, beyond which it encounters the summit of the country by means of a long tunnel; it thence passes on to Winterbut Lee, and continues by the Valley to Todmorden, which is thickly studded with the extensive mills of the Messrs. Fielden, and other large establishments. From thence it is carried on to Charlestown, where a slight divergence, causing very quick curves in the line, has been found necessary in consequence of the failure of

the tunnel at that place. From Charlestown the line is produced to Sowerby Bridge; and passing on the north of the ancient town of Elland, continues to Brighouse, Ledgard Bridge, and Dewsbury; thence passing by Horbury Bridge and Thornes to Wakefield; from whence it is traced through the township of Heath to its junction with the North Midland Railway at Normanton; the whole distance from the present Manchester station being 49·95 miles.

The curves are generally of about 60 chains radius; but there are three at Charlestown which have each a radius of 12 chains. This is caused by a diversion from the original line consequent upon the failure of the tunnel at that place. It is to be observed, that these quick curves are altogether for a length of only 300 yards. By moderating the speed of the locomotives while doubling this projecting feature of the country, the difficulty will be easily surmounted.

INCLINATIONS. — In point of gradients, this line comes under the second class. The summit is attained in 16·325 miles from Manchester, with a total rise of 331 feet 3·12 inches, which gives an average inclination of 1 in 260.

In this length there are eight planes; the first of which is level for 18 chains; the three next in order ascending at the rates respectively of 1 in 150 for 4 miles 6 chains, 1 in 1056 for 48 chains, and 1 in 152 for 2 miles 73 chains; thence succeeds a level plane, which is 44 chains in length; the sixth plane rises for 1 mile 62 chains, at the rate of 1 in 330, to Rochdale; the seventh plane is level for 2 miles 8 chains; and the eighth plane ascends for 4 miles 7 chains, at the rate of 1 in 330, to the summit, which is at the east end of the long tunnel. The summit level plane is 14 chains in length, from which to its junction with the North Midland Railway, a distance of 33·45 miles, the line descends by easy grades, except for the first plane, leaving the summit, which inclines, at the rate of 1 in 182, for 6 miles 30 chains. Besides this, there are nine other planes, which vary in inclination from 1 in 330 to 1 in 730. Four level planes are introduced in this length; the first of which is near the Calder Iron Works, near Thornhill Lees, and is half a mile in length; the second by Horbury Bridge, and is 42 chains in length; the third is below Wakefield, and is 3 miles 11 chains in length; and the fourth is at the junction with the North Midland Railway at Normanton; the whole fall from the summit being 437 feet 4·44 inches.

Taken in order from the summit, the lengths and inclinations are as follows:— 6 miles 30 chains, 1 in 182; 7 miles 63 chains, 1 in 377; 3 miles 17 chains, 1 in 730; 4 miles 75 chains, 1 in 440; 40 chains, level; 58 chains, 1 in 660; 1 mile 4 chains, 1 in 472; 1 mile 58 chains, 1 in 528; 50 chains, 1 in 660; 42 chains, level; 1 mile 20 chains, 1 in 660; 3 miles 11 chains, level; 1 mile 38 chains, 1 in 330; and 10 chains, level.

Referring to the original parliamentary section, we find that between Manchester and the summit the steepest inclines were at the rate of 1 in 165 for a collective length of 8 miles 51·50 chains; and by the line as laid out, the worst inclines are 1 in 150 and 1 in 152 for a collective length of 6 miles 79 chains. Further, by the original section there was only one level plane of 1 mile 35 chains in length, whereas by the present section the level planes in this length amount altogether to 2 miles 70 chains. Beyond the summit, the steepest inclines by the original section were 1 in 130 for 3 miles 67 chains, and 1 in 277 for 3 miles 56·50 chains; but by the line as carried into execution, the worst incline is at the rate of 1 in 182 for 6 miles 30 chains; and several level planes are interspersed, as will be seen above; whereas by the original section there was not one level plane between the summit and the eastern terminus; so that the section has been greatly improved from one end to the other.

EARTHWORKS.—The cuttings and embankments throughout this line are exceedingly heavy. Between Manchester and Littleborough the earthworks amount to 2,107,360 cubic yards, or at the average rate of 156,100 yards per mile; and throughout the whole line the quantity amounts to 5,020,000 cubic yards, or at the rate, on an average, of 100,500 yards per mile.

Among the principal works in this department may be mentioned the Moston cutting, with slopes of 2 to 1; the Burnley Valley embankment;* and the Horbury cutting. The slopes vary according to the strata, and are in some parts covered with vegetable mould, and sown with grass-seeds. In the slopes of some of the cuttings wooden troughs are introduced to carry off the surface-water into the side-drains below.

* This embankment contains 364,000 cubic yards.

There are several extensive diversions of the river Calder, the principal of which is at Kirkthorpe, below Wakefield, by which the cost of building two large bridges has very wisely been saved. These diversions were not effected without considerable opposition on the part of those interested in the navigation.

BRIDGES, VIADUCTS, &c.—The number of bridges throughout the line is one hundred and sixteen, or at the rate, on an average, of 2·32 per mile. The principal viaducts are at Manchester, Gaulxholm, Horsfall, Whiteley, and Wakefield; besides which there are ten large bridges, with from two to six arches each, spanning the river Calder. There are also an iron tie-bridge over the Rochdale Canal, similar to that over the Regent's Canal at the Camden depôt of the London and Birmingham Railway; a large skew-bridge across the canal at Hebden Bridge; and a level beam-bridge over Kirkgate, Wakefield. Towards Manchester, the bridges are built of brick; and for the remainder of the line chiefly of stone, with brick arches. The total quantity of masonry and brickwork in the bridges, viaducts, retaining-walls, &c. amounts to 5,319,000 cubic feet, or, on an average, at the rate of 106,586 cubic feet per mile.

TUNNELS.—There are altogether eight tunnels; the principal of which is at the summit of the line, through shales, rock, clays, bin, &c., and is 2860 yards in length; the second, at Winterbut Lee, also in treacherous strata, is 275 yards long; the third is at Castle Hill, near Todmorden; the fourth and fifth are at Horsfall and Charlestown, the latter of which is 250 yards long; the sixth, near Sowerby Bridge, is 638 yards in length; the seventh, near Elland, is 410 yards long; and the eighth is but for a short length, near Horbury, which has been substituted for open cutting, as had been originally intended. All the tunnels are lined either with brick or stone. The whole length of tunnelling, excluding that at Horbury, amounts to 5082 yards.

The summit tunnel, which is the principal work of the kind throughout the line, is 1 mile and 5 furlongs in length, 23 feet 3 inches at level of springing of invert, and 24 feet at springing-line of the semicircular arch or roof. The brickwork varies from five to ten rings in thickness, according to the nature of the strata in different parts. The height from springing-line of

invert to soffit of arch is 21 feet 6 inches. The east end, for a length of 3 chains, is on a curve of about 60 chains radius; and the west end, for a length of 12 chains, is on a radius of 49 chains.

The vertical shafts used for the execution of the tunnel are fourteen in number; twelve of which were worked by fixed engines, and the remainder by horse-gins. The shafts in order are distinguished as under, and have the following depths, commencing at the west end, viz. Shaft A, 57 feet; No. 1, 61 feet; No. 1½, 109 feet; No. 2, 170 feet; No. 3, 208 feet; No. 3½, 212 feet; No. 4, 227 feet; No. 5, 167 feet; No. 6, 212 feet; No. 7, 321 feet; No. 8, 295 feet; No. 9, 235 feet; No. 10, 108 feet; No. 11, trial shaft, and No. 12, 61 feet in depth, respectively: altogether 2443 feet in length, and containing about 70,000 cubic feet of brickwork. All the vertical shafts, except A, No. 1½, No. 3½, and No. 12, are of 10 feet diameter, and the others each of 9 feet diameter; the thickness of brickwork in the 10-foot shafts being 14 inches, and in the 9-foot shafts 9 inches.

The progress per day in the early part of 1840 was about 5 feet 3 inches; and during the spring and summer of the same year the progress was at the rate of 14 feet 1·24 inches lineal per diem, although the faces had been considerably decreased in number, by reason of numerous junctions. The west end of this tunnel was executed by an open cut, as part of the Primrose Hill, and the whole of the Kensal Green tunnels, on the London and Birmingham Railway. The brickwork is chiefly in cement. The bricks cost 40s. per thousand, delivered at the shafts. The cement is from near Hull, and is mixed with sand in equal proportions; the cost of the cement is about 2s. 3d. per bushel. The miners get 4s. 6d. to 6s. 6d. a day of ten working hours; and the bricklayers 6s. 6d. Each horse-gin was driven by two horses, which were attended by two boys. About a thousand men were engaged at a time during the progress of the greater portion of this work, which was prosecuted by night as well as by day. The contractor by whom it was chiefly executed is Mr. John Stephenson; and the engineers resident at this tunnel, Mr. Dickinson and Mr. Harding, who have had excellent opportunities of acquiring experience in this important branch of railway-engineering.

The works of the Charlestown tunnel, after a very considerable outlay, are entirely stopped, it being in a state totally unsafe for the workmen to proceed. Owing to a *débris* of the hill through which it was attempted to be

driven, the side walls have collapsed, and the masonry in parts is literally crushed to pieces. In consequence of this failure, a divergence of the line southward has been rendered necessary, which involves three curves, each having a radius of 12 chains. To all appearance the railway, at some future day, will be entirely stopped at this place, owing to the movement of the hill above alluded to.

GAUGE OF WAY, &c.—The gauge is 4 feet 9 inches, in order to allow $\frac{1}{4}$ of an inch play on either side for the wheels of the locomotives and carriages. The intermediate space is 6 feet 5 inches; and each side-space 7 feet.

The rails are of the single parallel form (see Plate 3, fig. 45), and the same as those used on the Blackwall, the Chester and Crewe, and part of the North Midland Railways. They are in 15-foot lengths, having 3-foot bearings, and are set in chairs measuring 10 inches by 5 inches, and secured thereto by a ball and key, as on the railways above mentioned. The key is of wrought iron, 8 inches long, $\frac{5}{8}$ -inch wide at one end, and $\frac{3}{4}$ -inch at the other; the balls, of cast iron, are each of $\frac{3}{4}$ -inch diameter (see Plate 16). The ball fits into a socket formed in one side of the stem of the rail. Stone blocks are used to a considerable extent, which are obtained from some of the cuttings; they are placed diagonally, and contain each 4 cubic feet. The sleepers used on the embankments are of larch, kyanized, being 9 feet long, and having a scantling of 11 inches by 5 inches.

The ballasting is chiefly of broken stone. Burnt stone is also used in some parts of the permanent way.

The fencing consists chiefly of stout posts, with four rails; in some parts of the line, however, stone walls are substituted; and, to a small extent, in the Manchester division, stone-flag Lancashire fencing is used (see Plate 16).

The mile-standards are placed at intervals of a quarter of a mile each.

STATIONS AND DEPÔT.—The Manchester station and depôt are situate between Lees Street and St. George's Street. There are several lines of way at this station, which is entirely elevated on arches. The passenger-shed is covered with a wooden roof in two spans. The booking-office is on the ground-floor; and the passenger-platform is approached by a flight of forty-

five steps, each of $7\frac{1}{2}$ inches rise. The whole length of the station is 176 yards, and the width 80 yards. The locomotive engine-house, which is removed to a little distance from the station, is of polygonal form, according to Mr. Stephenson's usual plan.

The intermediate stations are situate at Mill Hills, Blue Pits, Rochdale, Littleborough, Todmorden, Hebden Bridge, Sowerby Bridge, Brig-house, Dewsbury, Horbury, and Wakefield. At Normanton a temporary office is erected for the joint use of this Company and that of the North Midland Railway.

Although the stations are of a far less costly description than those of the North Midland Railway, it is certain that much expense might have been saved by a more simple style of building than is generally adopted throughout this railway. Surely the engineering works will cost quite enough, without swelling the sum total by the erection of so many Elizabethan villas. A very small building is required at most of the intermediate stations throughout the kingdom. Yet not only on this line, but on many others, the buildings erected at the intermediate stopping-places are on a scale of nearly sufficient magnitude for terminal stations.

CARRIAGE DEPARTMENT.—The carriages consist of first class, second class, and third class or Stanhopes.

The first-class carriages are in three compartments, and fitted up in the usual way. The weight of a first-class carriage is 8100 lbs.

The second-class are also in three compartments, and are open at the sides; but have wooden sliding-shutters instead of glass sashes. The space between the seats is inconveniently narrow. The weight of a second-class carriage is 6150 lbs.

The third-class, or Stanhopes, are 17 feet in extreme length, and 8 feet 8 inches in extreme width; at each end, for a length of 18 inches, the width is decreased to 5 feet. There are four entrances; and the whole is divided into four compartments by a wooden bar down the middle, and another across intersecting the first at right angles. The weight of this contrivance is 5050 lbs.; and the number of passengers it will contain depends on the bulk of the respective stanhopers. It has been stated that this description of carriage was put on the line merely as an experiment; but the scheme had

already been tried on other lines, and found not to answer, so far as the railway-proprietors are concerned. It is quite proper to accommodate the poorest class of passengers; but surely the conveyance should be provided with seats, to distinguish them from the brute beasts which perish.*

Besides the above, there is another description of carriage, similar to those used on the Scotch lines, which is mixed; the middle compartment being for first-class, and each of the end-compartments for second-class passengers respectively.

The carriages are all mounted on four wheels, and are hung on springs in the usual way. A perforated iron footboard, running the whole length of carriage, is substituted for the lower tier of steps, as in the railway-carriages of the North of England and Scotland.

The coke and cattle-trucks weigh each from 56 cwt. 3 qrs. to 60 cwt. 2 qrs.

Mr. Edmondson's ingenious ticketing system, which is adopted on this line, is considerably improved since it was first introduced on the Newcastle and Carlisle Railway, on which line Mr. Edmondson held the appointment of ticket-collector at one of the intermediate stations. We desire to see this simple yet effectual method generally introduced throughout the kingdom. The tickets are taken by the guards on the journey, oftentimes while the train is in motion; a practice attended with considerable danger, as was but too surely proved very recently. The guards are dressed in flaming red coats; and some of them carry horns, which, by the way, is worthy of imitation by other companies. Each station-porter has a glazed hat, and painted in conspicuous letters in front are the word "guard" and the number by which he is registered in the Company's books.

We found the average weight of seven trains on this line, in the months of August, September, and November, 1839, to amount to 41,238 lbs.; the average velocity to be at the rate of 25·29 miles per hour; the highest velocity to be 41·66 miles per hour (descending); and the stoppages to average each 1·813 minutes.

* At the stations east of Hebden Bridge we observed something like the following notice:—
"The Company's servants are strictly ordered not to porter for wagon-passengers." This, no doubt, is for the purpose of preventing those respectable-looking individuals whom we have so often seen among the wagon-passengers from availing themselves of this cheap mode of conveyance.

TRAFFIC, FARES, &c.—The line was opened to the public from Manchester as far as Littleborough on the 4th July, 1839; and between Norman-ton and Hebden Bridge on the 12th October, 1840.

The number of passengers conveyed by the trains from the opening on the 4th July, 1839, to February 3d, 1840, inclusive, amounted to 388,627, or at the rate, on an average, of 1807·56 per diem. The number of third to first-class passengers was as 28½ to 1; of third to second, nearly as 5 to 1; and of second to first, rather more than 5 to 1.

The fare for a first-class passenger between Manchester and Littleborough, 13½ miles, is 4*s.*; for a second-class passenger, 2*s.* 6*d.*; and for a third-class passenger, 1*s.* 6*d.*; or at the rates of 3·555*d.*, 2·222*d.*, and 1·333*d.* per mile respectively.

Private carriages with two wheels are charged at the rate of 6*d.* per mile; and with four wheels, 9*d.* Horses are charged at the rate of 6*d.*; and neat cattle at 2½*d.* per mile respectively. Sheep and pigs are conveyed by the hire of a wagon having a capacity equal to 380 cubic feet, and which is charged for at 1*s.* 6*d.* per mile, or at the rate of ·189 farthing per cube foot.

The locomotive engines used on this line are all mounted on six wheels, and are from the works of first-rate makers. Their proportions will be seen by reference to Table XVII. of British Locomotives, in the Appendix.

It is reported that this Company have agreed for the supply of fifty tons of coke per diem, from the Low Moor coal, at only 14*s.* a ton. If this be so, it will cause an immense annual saving in the item of “locomotive power, &c.”

RECEIPTS AND EXPENDITURE.—The revenue from passengers, &c. from 4th July, 1839, to 30th June, 1840, amounted to 35,080*l.* 2*s.* 8*d.*; and for goods and parcels to 5,219*l.* 10*s.* 9*d.*; together, 40,299*l.* 13*s.* 5*d.* Thus the receipts for passengers amounted to 96*l.* 12*s.* 9·47*d.*; and for goods and parcels to 14*l.* 7*s.* 6·93*d.* per diem respectively.

The expenditure for the same period amounted to 20,606*l.* 19*s.* 4*d.*, which is equal to 51·13*l.* per cent on the gross revenue; but during this period there was no charge for maintenance of way.

The cost of locomotive power per diem was, on an average, equal to 21*l.* 1*s.* 3·57*d.*; the coaching disbursements to 26*l.* 2*s.* 6·14*d.*; the police to

1*l.* 10*s.* 6·96*d.*; and the item of “salaries, office-expenses, advertising and printing, rates, taxes, &c.” to 8*l.* 0*s.* 11·75*d.* respectively.

The following shews the various items of expenditure from the 14th November, 1835, to 30th June, 1840 :—

Parliamentary expenses	£ 48,107	8	9
Engineering	93,048	2	3
Land and compensation, and attendant expenses	277,628	17	8
Works	1,446,494	0	3
Stations, on account	105,244	17	11
Direction	9,600	0	0
Travelling expenses	2,913	5	8
Advertising, printing, &c.	1,171	16	7
Secretary's office-expenses, including salaries, taxes, books, stationery, &c.	3,887	18	2
Law-charges for general business	6,345	17	4
Stores	3,188	7	5
Locomotive engines	38,694	2	1
Carriages	21,387	7	2
Wagons, &c.	4,649	12	3
Mortgage and bond-stamps, interest on mortgages, and interest on bonds	42,179	3	1
Surplus land and materials, &c. which are available for resale	29,730	3	8
	£ 2,071,651	0	3
Disbursements on account of land, &c. for the extension to Hunt's Bank, including the expenses of Act No. 3	42,337	15	4
	£ 2,113,988	15	7

The parliamentary estimate for this railway included the following items, and presents a strange contrast with the actual cost :—

Earthworks	£ 360,570
Masonry	226,579
Stations	10,000 !
Culverts	18,231
Alterations to roads and streams	4,626
Tunnels	74,255 !
Fencing	21,340

Formation of way, including rails, chairs, keys and pins, felt,	}	268,875
blocks, sleepers, and ballasting		
Contingencies, nearly 12 per cent		115,518
		<u>1,100,000</u>
Land and buildings		200,000
		<u>£ 1,300,000</u>

Thus the cost per mile (for the above included the whole distance to Leeds) was at the rate of about 21,443*l.* Up to the 30th June, 1840, the disbursements on account of the main line amounted to 2,071,651*l.*, or at the rate of 41,474*l.* 9*s.* 10·67*d.* per mile; and according to the directors' report, 100,000*l.* additional will yet be required to complete the arrangements throughout.

In concluding this account, we must not omit to congratulate the Company in having been fortunate enough to secure the services of Capt. Laws, who is ever at his post, and has introduced throughout the establishment a system of order and regularity, which we may look for in vain in some other works of nearly equal magnitude.

MIDLAND COUNTIES RAILWAY.

THE principal towns brought into immediate connexion by the Midland Counties Railway are Nottingham, Derby, Loughborough, Leicester, and Rugby, containing an aggregate population, according to the last census, of one hundred and fifty-two thousand souls.

By this railway the above important towns are connected with the metropolis, with Birmingham, Coventry, and all places on the London and Birmingham Railway, and its adjuncts; and by the North Midland, and other auxiliary lines, with Chesterfield, Sheffield, Barnsley, Wakefield, Leeds, York, and Hull.

Moreover, the Midland Counties Railway forms one of the main links in the present eastern grand trunk line between the metropolis and the north; and as such depends not simply on local traffic for its support, but on the

great mass of population moving continually to and fro between London and the counties of Leicestershire, Derbyshire, Nottinghamshire, Yorkshire, and the whole of the north-eastern portion of England.

ACTS OF PARLIAMENT, &c. — The Act for the incorporation of this Company received the royal assent on the 21st June, 1836, and authorised a capital to be raised in joint-stock of 1,000,000*l.*, and by loan 333,000*l.* In 1838 a second Act was obtained for amending the former; and in the session of 1840 a third Act was obtained, which received the royal assent on the 10th August, and empowered the Company to raise an additional sum of 200,000*l.*, of which 150,000*l.* was to be by shares, and the remainder by loan, making a total of 1,533,000*l.*

The number of original shares is 10,000 of 100*l.* each, and of new or quarter shares also 10,000 of 25*l.* each. The capital of the Company in shares, therefore, is 1,250,000*l.*

The first opening of the line took place on 4th June, 1839, with a single line of way between Nottingham and Derby. The second opening, which was of those portions of the line extending from Nottingham and Derby to Leicester, occurred on the 5th May, 1840; and it was opened to the public throughout on 1st July following.

GENERAL COURSE OF THE LINE.—Leaving the London and Birmingham Railway south of the original Rugby station, at a distance of eighty-one miles from London, the line proceeds in a slightly curving course, by Ullesthorpe, Broughton, Wigston, Leicester, Syston, Sileby, Barrow, Loughborough, Long Eaton, Sawley, and Burrowash; thence nearly in a direct course to Derby, the distance between Rugby and Nottingham being 48 miles 8 chains. The Nottingham branch leaves the main line north of Long Eaton, at a distance from Rugby of 39 miles 13 chains, and curving into a direction about north by east proceeds by Beeston to Nottingham; the whole length of this branch being 7 miles 16 chains, and the distance between Rugby and Nottingham 46 miles 29 chains.

The line between Derby and Nottingham is made up of part of the main line, part of the branch from the main line diverging near Long Eaton, and by an additional length of about 2½ miles, which may be called the junction-

line, as it forms the middle length of the railway between Derby and Nottingham. The distance between these places is $15\frac{1}{4}$ miles; so that the whole length of double line will be about $57\frac{1}{4}$ miles.

The following table exhibits the lengths and inclinations of the main line, between the London and Birmingham Railway near Rugby and the trijunct station at Derby:—

Lengths of Planes.				Ratio of Inclination.	
Miles.	Chains.				
	40	.	.	level.	
5	10	.	.	ascending at the rate of 1 in	330
2	12	.	.	descending „	1 in 420
7	30	.	.	descending „	1 in 354
	18	.	.	level.	
3	18	.	.	descending „	1 in 387
	32	.	.	descending „	1 in 704
	40	.	.	level.	
2	20	.	.	descending „	1 in 495
1	30	.	.	level.	
	37	.	.	descending „	1 in 349
2	56	.	.	level.	
5	17	.	.	descending „	1 in 504
	50	.	.	level.	
1	20	.	.	ascending „	1 in 1333
1	00	.	.	level.	
	45	.	.	ascending „	1 in 1120
	40	.	.	level.	
2	57	.	.	descending „	1 in 550
1	01	.	.	level.	
1	00	.	.	ascending „	1 in 1320
	53	.	.	descending „	1 in 874
	14	.	.	level.	
3	40	.	.	ascending „	1 in 883
1	02	.	.	ascending „	1 in 541
	46	.	.	level.	
2	00	.	.	ascending „	1 in 503
<hr/>					
48	08	to junction with North Midland Railway at Derby.			

The summit of the line is 5 miles 50 chains from its junction with the London and Birmingham Railway, and 82 feet above the level of the rails

at the point of divergence, and 154 feet above the level of the rails at Derby. The aggregate length of level planes is 8 miles 55 chains.

The Nottingham branch is 7 miles 16 chains in length, and has seven planes, three of which are descending towards Nottingham, and have inclinations of 1 in 416, 1 in 1060, and 1 in 528; one ascending at the rate of 1 in 880; and three level, amounting in length to 3 miles 42 chains.

It will be seen, by reference to the above, that this line in point of gradients comes entirely within the first class of railways.

EARTHWORKS, &c. — The earthworks on this line taken throughout are not nearly so heavy as those of the London and Birmingham Railway, the average quantity per mile being 94,112 cubic yards, or 5,335,000 of cutting throughout, of which 400,000 yards are deposited in spoil; whereas in the latter the cubical contents of the cuttings amount on an average to 142,000 yards per mile. On the Midland Counties line there are also 170,000 yards of side-cutting; making the total average quantity per mile equal to 95,324 yards.

The heaviest works in this department are between Rugby and Leicester, amounting to upwards of three millions of cubic yards in 20 miles, or at the rate of rather more than 150,000 yards per mile. The largest work is between Leicester and Rugby, called the Leir cutting, containing 602,000 yards, its greatest depth being 62 feet, and the slopes formed at 2 to 1; and the earthwork next in order in point of magnitude is the Leir embankment, containing 430,000 cubic yards, and being about 40 feet high, also with slopes of 2 to 1.

The whole of this contract, extending from Rugby to Leicester, was executed by Mr. M'Intosh, in his usual spirited manner.

The longest lead throughout the works was 4 miles, and the shortest one mile.

Mr. Woodhouse informs us, that the average cost throughout was at the rate of 13*d.* per yard.

The works have been carried on by night as well as by day; and in August 1839 there were no fewer than 3700 men and 370 horses engaged at one time, besides two locomotives and one fixed engine.

The wages of artificers employed on this work were as under:—Navi-

gators from 2*s.* 9*d.* to 3*s.* and 3*s.* 3*d.*; bricklayers from 3*s.* 6*d.* to 4*s.* and 4*s.* 6*d.*; masons from 4*s.* 6*d.* to 5*s.* 6*d.*; and carpenters 3*s.* 6*d.* each per diem respectively.

BRIDGES, VIADUCTS, &c. — The whole number of bridges on the main line from Rugby to Derby amounts to 148, of which 64 are over, and the remainder under the railway. The level road-crossings are 12 in number, and the field-crossings 58 between the same points respectively.

Guard-rails are introduced at the level crossings; and gates are set up, which shut either across the railway or road as required.

The principal viaducts are those over the rivers Avon, Trent, Soar, and Wreak. The Avon viaduct is near the Rugby junction, and consists of eleven semicircular brick arches, each of 50 feet span, the piers being each 9 feet wide at base, and 8 feet at springing, the height of viaduct being 40 feet; and that over the Trent, which is near Long Eaton, consists of stone piers and abutments, and three cast-iron Gothic arches, each of 100 feet span, with a rise of 10 feet. There are six ribs, each of which is in three pieces, the outer ribs weighing each 33 tons, and the inner ones 27 tons respectively; the total weight of iron work is 800 tons. The piers are each 10 feet wide at the level of ordinary summer-water; the height from the same to the level of the rails being 19 feet 6 inches. One of the piers is founded on a grating of timber; and the other pier and abutments are carried down to the stratum of marl. The height of piers from the foundation to springing line of arches is 26 feet.

The river Soar viaduct consists of five arches, each of 30 feet span; and that over the river Wreak consists of two arches, each of 36½ feet span.

The bridges over the railway are generally of semi-elliptical form, having a versed sine of 10 feet and a span of 30 feet, the height being 16 feet in the clear. The arches are built in four rings. The width between the parapets of bridges under the railway is 27 feet. The occupation-arches under the railway are each of from 12 to 15 feet span.

The bridges almost throughout this line are built of red brick, the copings and strings being formed of hard-burnt brick-earth, of the particular form required, as on the South-Eastern Railway. This plan might be advantageously carried out in many other districts where brick-earth is abundant.

TUNNELS.—There are three short tunnels; the first, through Red Hill, 150 yards in length; the second, at Gill's Corner, near Lutterworth, which is 66 yards long; and the third, at Knighton, south of Leicester, which is 100 yards in length. The tunnels are all lined with brickwork.

The Red Hill tunnel is constructed of 18-inch brickwork, the arch of which is of semicircular form; and the clear width at level of the rails is 24 feet. The bricks used at this work cost from 26*s.* to 28*s.* a thousand.

The Knighton tunnel is also of brickwork. The arch, which is of parabolic form, is 2 bricks, and the side-walls 3 bricks, in thickness. The clear width of the tunnel at springing of the arch is 27 feet, and at the level of rails 24 feet 10 inches. The invert is of segmental form, with a versed sine of 2 feet.

The Lutterworth tunnel is 25 feet in width and 24 feet high.

GAUGE, RAILS, &c.—The gauge of way is 4 feet 8½ inches; the intermediate space 6 feet 5 inches; and each side-space 3 feet in width. On some of the embankments, however, the side-spaces are considerably wider than 3 feet; on bridges they are 5 feet 7 inches each, making the clear width between parapets 26 feet. The whole width of land enclosed, independent of slopes, is 45 feet.

The rails are chiefly of the double parallel form, in 15-foot lengths, and of 77 lbs. weight to the yard lineal (see Plate 3, fig. 46): they are set in chairs, with 5-foot bearings; those for the joints weighing each 28 lbs., and the intermediate chairs 23½ lbs. each, and secured thereto by wooden keys (see Plate 16), according to the now generally adopted method; the joint-keys being 6 inches long, and having a scantling of 4½ inches by 1½ inches; and those for the intermediate chairs being 4½ inches long, and measuring 4½ inches by 1½ inches. The whole are of compressed oak, the cost being at the rate of 12*l.* per thousand.

Cross sleepers are used on the embankments and in some of the cuttings, 9 feet long, and measuring 10 inches by 5 inches; those of oak being each worth from 6*s.* 3*d.* to 6*s.* 6*d.*, and those of kyanized larch 5*s.* each, respectively. The stone blocks each contain 5 cubic feet, and are placed diagonally in the cuttings; they are formed of the Cromford Mill stone-grit, and cost from 4*s.* to 6*s.* each. The spikes for securing the chairs to the blocks and sleepers are 5½ inches long, and weigh each ¾ lb.

Some portion of the way towards the Rugby junction is laid with Evans's dove-tailed bridge-rails, 57 lbs. to the yard (see Plate 3, fig. 47), on longitudinal Memel timbers, which are 14 inches by 7 inches in substance, and all kyanized. The transverse sleepers are of pine kyanized, and are each 9 feet in length, and measure 9 inches by $4\frac{1}{2}$ inches. The rails are secured to the longitudinal timbers with $\frac{5}{8}$ -inch screws, 5 inches long, and sixteen in number, to each 15-feet rail.

Open side-drains are used at the bottom of the slopes of both cuttings and embankments; they are 7 feet wide at top, 1 foot at bottom, and 18 inches deep. Semicircular open brick-drains are introduced to carry the water from the slopes of cuttings into the drains below. Cross rubble-drains are also used at intervals of 11 yards each.

The ballasting is chiefly of gravel, two-thirds of the whole line being thus laid, and the remainder with sand and sandstone pulverised. The depth of ballasting under the blocks is 12 inches; and the whole width 8 yards. The ballasting throughout has cost from 2s. to 2s. 6d. per cubic yard.

The wooden fencing is not quite in keeping with the rest of the work, having generally a very frail appearance. In some parts of the line it consists of posts, 9 feet from middle to middle, and three rails, with an intermediate upright stay; and in others of three rails and space and pale for the lower half, which is the best description of fencing that can possibly be introduced in grazing districts.

The width of land at top of the slopes, including the ditch and bank for the hedge, is 9 feet.

The mile-standards are of wood, and placed at intervals of a quarter of a mile. The size of one of these standards is 5 inches by 5 inches, and 5 feet high above the ground. The head of each is considerably larger than the stem, and presents two faces towards the railway, on one of which is painted the down, and on the other the up distance.

STATIONS. — Besides the principal stations at Derby, Nottingham, and Rugby, there are altogether twelve intermediate stations on the main line, which, taken in order, are at the following places, with their distances respectively from the Rugby junction: — Ullesthorpe, $7\frac{1}{2}$ miles; Broughton, 11; Wigston, $16\frac{1}{2}$; Leicester, 20; Syston, $24\frac{1}{2}$; Sileby, $27\frac{1}{2}$; Barrow, 30; Lough-

borough, $32\frac{1}{2}$; Kegworth, $37\frac{1}{2}$; Long Eaton, $40\frac{1}{2}$; Sawley, $42\frac{1}{2}$; and Burrow-Ash, $44\frac{1}{2}$; besides Beeston, which is on the Nottingham branch.

At the Rugby station there are several lines of way, with a passenger-shed of considerable length, the roof of which is supported in front by 42 cast-iron columns, and in the rear by a brick wall, which also forms the front of the booking-offices and waiting-rooms. On either side of this shed, in which there is only one line of way, with side-spaces, each of $2\frac{1}{2}$ feet, is a paved platform 9 feet in width.

The Nottingham station is situate at the end of the railway, as the Nine Elms station of the London and South Western Railway. The elevation next the road to Nottingham is of plain but neat design. It consists of a central portion and two wings; the central portion contains the entrance-hall, which is of the whole height of the building. In the right wing is the booking-office for first and second-class passengers, with windows (looking to the hall) at which the passengers receive their tickets; the third-class passengers obtain their tickets at a counter fixed in the hall. In the left wing is the board-room and clerks' offices; and in a building projecting towards the passenger-shed in the rear is a waiting-room for ladies.

The shed is covered with a light iron roof in two spans, which is supported on the departure-side by a brick wall, in which are eight windows; and on the arrival-side, and along the middle line, by two rows of cast-iron columns, nine in each row.

There are four lines of way at this station, and as many turn-tables without the shed; the cross line intersecting which communicates with the carriage-wharf or landing, which is on the arrival-side.

The arrival-passengers leave the station by gates at the side of the offices opening into the road in front, and altogether similar to the arrangement at the Nine Elms station above alluded to.

The locomotive engine-house, which is a little removed from the passenger-shed, and on the arrival-side of the railway, is constructed of brick-work, having two lines of way running quite through it, and which communicate with the main line. This building will hold six four-wheel engines and four tenders. Its clear width is 25 feet 8 inches. The gateways at each end are each 9 feet $8\frac{1}{2}$ inches in width. The engine turn-tables are of wood, and 14 feet in diameter.

The Leicester and Loughborough stations are the principal intermediate stopping-places; that at Leicester is rather on an extensive scale. The passenger-shed is very properly placed off the main line, as is the case with the New Coventry station on the London and Birmingham Railway.

The Ullesthorpe station is very inconveniently placed at the top of a deep cutting at that place.

The buildings at the minor intermediate stations are generally erected in the plain cottage style, and of red brick.

An account of the trijunct station at Derby will be found under the North Midland Railway description.

LOCOMOTIVE ENGINES AND CARRIAGES. — The engines used on this line are chiefly mounted on four wheels, and built according to Mr. Bury's plan of construction, the driving-wheels being each of $5\frac{1}{2}$ feet, and the leading-wheels of 4 feet diameter respectively, with 12-inch cylinder and 18-inch stroke (see Plate 6).

The carriages consist of mails, and first, second, and third-class coaches, besides which there are second-class closed carriages for the night-trains. The first-class carriages will each hold eighteen passengers, and the second class twenty-four passengers, also in three compartments. The third class are furnished with seats, as on the Grand Junction Railway. The length of a third-class carriage is 15 feet, and its breadth 8 feet.

Stanhopes were used on this line when first opened to the public, but have very properly been discontinued.

FARES, TRAFFIC, &c. — By their Act of incorporation this Company is empowered to charge a maximum toll of $2d.$ per mile for every person conveyed in or upon any carriage travelling upon the said railway, exclusive of locomotive power and the use of carriages.

On the opening of the line between Nottingham and Derby on 4th June, 1839, the first-class fares were at the rate of $3\cdot096d.$ per mile, and the second-class fares $1\cdot935d.$ On the 24th of the same month the first-class fares were reduced to $2\cdot700d.$, and the second-class fares to $1\cdot547d.$ per mile respectively.

At the present time (November 1840) the first-class fares on the main line from Rugby to Derby are at the extraordinarily low rate of only $1\cdot913d.$,

and the second-class fares 1·673*d.* per mile for through-passengers in each case respectively.

From the 4th June to the end of the year 1839 the receipts for passengers on the line between Derby and Nottingham amounted to 8569*l.* 13*s.* 8*d.*, or at the average rate of 40*l.* 12*s.* 3·31*d.* per diem; and for goods to 707*l.* 4*s.* 11½*d.*, or at the rate on an average of 3*l.* 7*s.* 0·45*d.* per diem.

During the above period the total number of passengers conveyed on this line amounted to 124,324, or at the average rate of 589·21 per diem. The proportion of second-class passengers to first was nearly as two to one; and of second to third (Stanhopes) (for the latter four months of the year) nearly as five to one.

The number of passengers conveyed by the trains (the line being opened throughout) in fourteen weeks, ending October 17th, 1840, amounted to 151,992½, or at the rate on an average of nearly 1551 per diem. The gross receipts for this period amounted to 21,435*l.* 17*s.* 10½*d.*, of which sum the proportion for passengers was 15,611*l.* 0*s.* 3*d.*, giving an average of 159*l.* 5*s.* 11*d.* per diem.

The number of passenger-trains daily in each direction at the present time (November 1840) is six; so that the miles run by the Company's engines with passenger-trains is equal to 693 daily.

ESTIMATE, COST, REVENUE, &c.—The parliamentary estimate for this railway was at the rate of 15,000*l.* per mile.

The following exhibits the cost of the undertaking from its commencement up to 1st July, 1840 :—

Parliamentary expenses	£17,253	15	7
Land and compensation	£ 209,624	14	4
Conveyancing, &c.	7,560	6	4
	<hr/>		
	217,185	0	8
Works and stations	933,804	18	8½
Locomotive engines, carriages, and machinery	48,556	7	0½
Engineering	12,163	16	9
Law-charges	1,745	8	3
Direction	4,500	0	0
Police	1,208	2	11
Office-expenses and salaries	4,141	15	11½

Advertising, printing, and stationery	1,874	16	11
Sundries, including travelling expenses	3,746	17	3½
Taxes and poor's-rates	246	6	9
Interest on debentures	£ 6,422	8	11
Debenture-charges and stamps	2,451	1	0
Commission and interest	2,510	7	9
		11,383	17 8
		£ 1,257,811	4 6

Thus the gross cost per mile, up to 1st July, 1840, of the Midland Counties Railway amounted to 21,780*l.*, and the net cost to 20,470*l.*, being an excess of 5470*l.* per mile above the parliamentary estimate; which is a more favourable result as regards the estimate than that of many of the great lines of the kingdom.

From the opening of the railway on the 4th of June, 1839, to 27th June, 1840, the total receipts on account of passengers, mails, merchandise, parcels, carriages, horses, and dogs, amounted to 20,071*l.* 14*s.* 8*d.*; and the disbursements in the locomotive and coaching departments, including general charges, and rates, taxes, and mileage-duty, to 11,320*l.* 15*s.* 8*d.*, being at the rate of 56·40*l.* per cent on the gross revenue. The item "maintenance of way" in this account is only 158*l.* 5*s.* 3*d.*, as the line had only been opened a little more than twelve months; so that this result is not so exceedingly favourable.

In conclusion, we may briefly mention that this railway was laid out by Mr. Vignoles, who is still consulting engineer to the Company; and the whole of the works have been executed under the immediate direction of Mr. Thomas Jackson Woodhouse, who also superintended for Mr. Vignoles the Dublin and Kingstown Railway.

NEWCASTLE AND CARLISLE RAILWAY.

WHOEVER is in the habit of travelling on the railway between Newcastle and Carlisle will be forcibly struck with the sinuosities of its course throughout. Yet, notwithstanding this apparent impediment to speedy locomotion,

no railway in the kingdom is better regulated in point of punctuality of the arrivals, especially of the quick trains, nor is there any upon which fewer accidents have occurred. A snakelike motion, however, and frequent jerks, are consequences of this curvilinear course; and unless it had been originally laid out for a railway or tram-road to be worked by horses, no engineer would have ventured to recommend a plan which exhibits on the face of it almost one continuous series of curves from end to end.

The line was originally surveyed under the direction of Mr. Thompson. Mr. Giles was afterwards appointed engineer; but Mr. Blackmore, under whose direction so much of the work has been executed, is at present engineer to the Newcastle and Carlisle Railway Company.

ACTS OF PARLIAMENT, SHARES, &c.—The Act of incorporation received the royal assent on the 22d May, 1829, and authorised the Company to raise a joint-stock capital of 300,000*l.* in 100*l.* shares, and by loan 100,000*l.* additional, so soon as the share-capital should be paid up. A second Act was passed on the 23d June, 1832, which empowered the Company to raise the 100,000*l.* as above, previously to the whole of the capital being received. On the 17th June, 1835, a third Act received the royal assent, authorising an addition to the joint-stock capital to be raised of 150,000*l.* The fourth Act was passed in the session of 1838, and gave the Company powers to raise by shares an additional sum of 300,000*l.*, and by loan 100,000*l.* Thus the total sum authorised to be raised amounts to 950,000*l.* Of this amount the sum of 300,000*l.* was raised by 3000 original shares of 100*l.* each; 90,000*l.* by 3600 25*l.* shares; 150,000*l.* by 3000 new shares; and 160,000*l.* was borrowed of the Exchequer Loan Commissioners, in two loans; the first of 100,000*l.*, which was to be paid off in four years, with an interest of six per cent, and the second at an interest of five per cent from the date of the loan.

OPENINGS OF THE LINE.—The line was partially opened on March 9, 1835; but it was not until the 18th June, 1838, that the line from Redheugh, on the south side of the Tyne, to Carlisle was opened throughout; and from the temporary station near the Infirmary at Newcastle to Blaydon, about four miles from Redheugh, the remaining portion of the railway, was opened to the

public in October, 1839; the first Act of Parliament having been obtained in 1829, and the works commenced in 1830.

GENERAL COURSE OF THE LINE.—Leaving the Newcastle station near the Infirmary, the line passes on the north of the river Tyne, and through the parish of St. Nicholas, to Scotswood, where the railway is carried over the river by a wooden bridge. It thence follows the valley of the Tyne for many miles, continuing by Blaydon (where the Redheugh branch diverges), Ryton, Wylam, Prudhoe, Stocksfield, Riding Mill, Corbridge, Hexham, Fourstones, Haydon Bridge, Bardon Mill, Haltwhistle, Greenhead, Rose Hill, Low Row, Milton, How Mill, Wetherall, and Scotsby, to the Carlisle station on the London road, and thence to the dépôt by the Canal Basin, Carlisle; the whole distance being 61 miles 67 chains.

Besides the main line, there is the branch to Redheugh, where a junction is effected with the Brandling Railway.

Except for about twenty miles, the whole is a double way; and we understand it to be the intention of the directors, on account of their mixed and increasing traffic, gradually to effect a double way throughout.

INCLINATIONS.—Commencing at the Newcastle station, the inclinations and lengths of planes are as follows:—

Lengths of Planes.		Ratio of Inclination.	Locations.
Miles.	Chains.		
13·03	level.	
20·07	descending at the rate of 1 in 265	
6·59	descending „ 1 in 580	
10·00	descending „ 1 in 250	
46·52	descending „ 1 in 190	
36·82	descending „ 1 in 220	
1 16·21	descending „ 1 in 270	
21·51	level.	
49·25	descending „ 1 in 200	Blaydon.
6 62·00	ascending „ 1 in 1106	
3 3·00	ascending „ 1 in 356	
3 71·00	level	Corbridge.
3 7·00	ascending „ 1 in 700	
7 49·00	ascending „ 1 in 423	Haydon Bridge.
13 12·00	ascending „ 1 in 393	Greenhead.

Lengths of Planes.				Ratio of Inclination.		Locations.	
Miles.	Chains.						
1	49·00	.	.	ascending	„	1 in 250	Summit level.
6	4·00	.	.	level	.	.	Milton.
3	35·00	.	.	descending	„	1 in 176	Cowran cutting.
3	70·00	.	.	descending	„	1 in 106	Corby viaduct.
3	65·00	.	.	descending	„	1 in 215	River Peteril.
1	60·00	.	.	level	.	.	{ Carlisle depôt by the Canal Basin.
61	67·00	.	.				

The branch from Blaydon to Redheugh is 3 miles 63 chains in length, and descends from the former place at the rate of 1 in 49·99; so that the whole length of railway is 65 miles 50 chains. In point of gradients this line comes under the second class of railways.

CURVES.—To describe all the curves would occupy too much space. We have already stated that it is almost a curvilinear line from end to end. The radius of curvature is from about a quarter of a mile upwards.

EARTHWORKS.—There are some heavy works in this department; the chief of which is the Cowran Hill cutting, through which it had originally been intended to carry the railway by a tunnel. The strata intersected consist chiefly of clay, with intermixed veins of sand. The length is about one mile; the average depth, 43 feet; and the greatest depth, 110 feet. The width of this cutting at level of rails is 26 feet. The sides are carried up with slopes of $1\frac{1}{2}$ to 1; and below the slopes is a retaining wall on either side, built of stone, 14 feet in height, 2 feet wide at top, and having a sufficient batter from the railway. On the top of each retaining wall is an open drain, which receives the water from the slope; and by means of vertical drains, which are connected with the main drains running under, and having the same inclination as the railway, the surface-water is entirely emptied into How Beck. A great deal of the excavated earth was carried to the embankment westward; and much also was thrown out to spoil. The total quantity excavated was something like a million of cubic yards; and Mr. Blackmore informed us that it was executed by contract, at so small a sum as 6*d.* per cubic yard.

On the branch from Blaydon to Redheugh the embankment, which is shallow throughout, is about 23 feet in width at the top, the intermediate space being 5 feet 3 inches. This embankment is formed chiefly from side-dykes, running parallel to the railway.

BRIDGES AND LEVEL CROSSINGS.—On our view of this line we counted twenty-five bridges over the railway and sixty-six under, sixty-one level road-crossings, and ninety-five field-crossings. In the neighbourhood of Carlisle the bridges are built of red sandstone; and, where carried over the railway, are 21 feet 6 inches in span.

The Corby viaduct, which crosses the river Eden about $3\frac{1}{2}$ miles from Carlisle, at an elevation of 100 feet above the usual level of summer water, is a work of no ordinary pretensions. It is built chiefly of red sandstone, and faced with stone from Newbiggin quarry, about four miles distant. The arches are five in number and semicircular, each of 80 feet span. The piers are each 16 feet in thickness. The total width of this structure is 25 feet, and clear width between the parapets, 22 feet. The whole length is 564 feet, including the abutments, which are each 50 feet in length. The cubical content of stone was stated by Mr. Blackmore to amount to 350,000 feet, which cost not more than 12*d.* per cubic foot.

At Carlisle, near the coal-dépôt, there is a viaduct of eight arches passing over the Maryport Road and low ground contiguous.

There are several bridges of wood spanning the rivers. The chief one is that at Scotswood, carrying the railway over the Tyne, at an elevation of 35 feet above the level of low water. It has eleven openings; the piers are constructed of whole-timber piles properly braced; and the abutments are of stone.

There is another bridge which we must not omit to notice: it is that over the Scotswood Road, being constructed on the skew principle. It is 30 feet on the square, and 50 feet on the skew-span, and 30 feet high above the road. It is built of iron and stone, having five girders, weighing together 70 tons. The parapets are of rubble walling, coped with masonry. The whole presents a useful and economical piece of workmanship.

On the branch to Redheugh there is a bridge of singular construction, which carries a coal-way over the line. This bridge, which is of wood, and

3 feet 4 inches wide, represents, as it were, the skeleton of lock-gates, consisting of four trussed portions, each hung folding, the meeting parts being furnished with small wheels, which run on iron segments when the gates are opened, for the purpose of allowing the locomotives to pass.

There are two very short tunnels on the main line.

On the extension-line to the canal-basin at Carlisle there are two pair of gates, which shut across a level road-crossing near that city, and also across the railway when required. The gate-posts, which are 11 inches wide \times 10 inches thick, are 22 feet asunder: this is the clear space left for the railway. Each gate is 10 feet 10 inches long, and 4 feet 9 inches high; the hanging post is 5 inches by $3\frac{1}{2}$ inches; the meeting post, 2 inches by $2\frac{1}{2}$ inches. There is also an upright stay, about 3 feet from the meeting post. The top-rail is 3 inches by 3 inches; and the other five bars 4 inches by 2 inches each. The gates are properly braced, and hung to each post with two stout hinges 29 inches long.

The width of land varies considerably in different parts: on the Carlisle basin branch, which is a double way, the whole width, including open drains, is 30 feet. On the main line leaving the Newcastle station, where there are four sets of rails, the whole width of land is about 58 feet. Between the parapets of bridges carrying the railway over roads, &c., the whole width is 22 feet.

GAUGE OF WAY, RAILS, &c.—The gauge is that of the English standard, viz. 4 feet $8\frac{1}{2}$ inches. The intermediate space varies in different parts of the line: thus at the Carlisle station, under the passenger-shed, it is 5 feet $1\frac{1}{2}$ inches; on the Corby viaduct, 5 feet; at the Milton station, 5 feet; on the embankment between Blaydon and Redheugh, 5 feet 3 inches; at the Newcastle station, 6 feet 6 inches; and in some parts it is 4 feet $8\frac{1}{2}$ inches between the inner rail of each way, as at Haltwhistle station.

The side-spaces are also of various widths; being at the Newcastle station 6 feet 6 inches and 12 feet respectively; on the extension to the canal-basin, at Carlisle, 5 feet; on the embankment of the Redheugh branch, 4 feet; at the Redheugh station, 6 feet; and on the Corby viaduct, 3 feet 9 inches, respectively.

The original rails used on this line weigh 42 lbs. to the yard, and are of

the fish-bellied form, in 15-foot lengths, with jump-joint ends. They are $3\frac{1}{2}$ inches deep at ends; in the shallowest parts, 3 inches; and at the middle of the bellies, $4\frac{1}{2}$ inches.

The rails now being used are of the parallel form (see Plate III. figs. 48 and 49), and weigh from 47 to 50 lbs. to the yard lineal. They are in 12 and 15-foot lengths, fixed in chairs with 3-foot bearings, having two iron keys to each chair $6\frac{1}{2}$ inches long, $\frac{7}{8}$ -inch wide, $\frac{1}{2}$ -inch at the top, and $\frac{1}{4}$ -inch at the bottom. The joint-chairs weigh 20 lbs. each; and the intermediate chairs, which measure $9\frac{1}{2}$ inches by $4\frac{1}{2}$ inches, and $4\frac{1}{2}$ inches high, the socket for the rail being $1\frac{1}{4}$ inches in width, and the chase for the keys on either side being together $1\frac{1}{2}$ inches in width, 16 lbs. The pin-holes are $1\frac{1}{2}$ inches diameter at top, and $1\frac{3}{8}$ inches at bottom. The chairs are attached to the blocks, or sleepers, by wooden pins, each of $1\frac{3}{8}$ inches diameter. On the curved portions of the Redheugh branch the rails are kept from spreading by iron ties turned up at each end under the bottom of the rails, and placed at intervals of 10 yards.

The way is chiefly laid with blocks, as it passes to a great extent through a stone district. At Carlisle the blocks, which are used as well on embankments as in cutting, are of red sandstone, 2 feet square and 9 inches thick. It is the opinion of some practical men, and we entirely agree with them, that it is eventually more economical to introduce wooden sleepers throughout, even in a district where stone is abundant, on account of the enormous expense of keeping a permanent way in repair which is laid with stone blocks. The wooden sleepers are 8 feet in length, and have a scantling of 9 inches by 4 inches.

Small coal, cinders, and also loam, are used to a considerable extent for ballasting the way.

On the Carlisle coal-depôt extension the open drains are 2 feet 9 inches wide. In the slopes of cuttings small semicircular open drains are used to draw the water off from the field-drains at top. In the Cowran cutting the drain runs down underneath the middle of the way, and receives the water from the slopes by cross drains placed at convenient distances.

The fencing consists of close boarding at some of the stations; stone walls 18 inches in thickness; and post-and-rail fence, some with three, others with four, and a third description with five rails each. Where the railway

runs parallel and close to main roads, it is separated from them by high close-boarded fencing.

The mile-standards, when we were last on this way, in the latter part of 1839, were placed only on one side, and that only at certain parts of the line, which is very inconvenient on many accounts, and gives to the railway an unfinished appearance.

STATIONS AND DEPÔTS. — Besides the terminal stations at Newcastle and Carlisle, there are no fewer than nineteen intermediate stations, at all of which, if necessary, the mixed trains stop to take up or set down passengers: to these may be added the station and depôt at Redheugh and the coal-depôt at Carlisle.

At the Newcastle terminus there is but a temporary shed at present; but the intended station and depôt are to be on a large scale, the land taken for this purpose not being less than fifteen acres. There are four lines of way leaving the temporary station.

The Carlisle station and depôt are contiguous to each other, and are situate close to the London road, and about a quarter of a mile from and to the south of the city of Carlisle.

The booking-office is in a neat detached rustic building; but is inconveniently situate with respect to the passenger-shed, which is on the other side of the station; so that passengers, having taken their tickets in the office, have some little way to go before reaching the carriages.

The passenger-shed has two lines of way running through it; but it is entirely without platforms. This, however, is of less consequence, as the carriages are hung much lower than usual, and are furnished with foot-boards.

The goods-shed is also detached, and is on the same side of the railway as the booking-office, and opposite to the passenger-shed. There is a pumping-engine of 3-horse power at this station for supplying the tanks with water.

The Landsale coal-depôt is in the rear of, and at a little distance from, the booking-office and goods-shed. It is of quadrangular form, having a shed on two sides and one end, enclosing an open space for common road-carts, which enter and leave this depôt under the end nearest the London road, from which there is an entrance distinct from that to the passenger-station.

The railway, which communicates with this depôt by means of turn-tables on two sidings running parallel to and between it and the passenger-station, passes in the middle of and along both the sides and ends, with a turn-table at each angle. Underneath each side are twenty cells for common road-carts, into which the coals or lime are discharged from the railway-wagons above by openings left between the rails and a proper flap in the bottom of each wagon. The railway also communicates by short branches with the locomotive engine-house and the repairing-shops. The engine-house will hold eight engines and tenders. The engine turn-tables are each of 13 feet 6 inches diameter.

The Carlisle depôt and station occupy altogether about six acres of ground.

The depôt at the canal-basin, Carlisle, is furnished with several lines of way, with turn-tables arranged for transferring the loads from the railway to the basin. Vessels are loaded from the railway-wagons by means of a draw-bridge, having rails fixed on it, and an opening between them, through which the coals are shot into the vessel by suitable machinery. This bridge is let down over the hold of the vessel, which is brought alongside the wharf-platform, and being sufficiently laden, the bridge is again drawn up.

At the Redheugh station and depôt there are four lines of way, running parallel to the river Tyne, with a quay extending the whole length. Two cranes are conveniently placed for loading and unloading vessels and the railway-wagons.

There are two goods-sheds in a line with each other near to the edge of the quay; each shed will hold five wagons. Between the sheds, through which a single line runs, there is a turning platform, by which the loads are transferred on to the main line. There is also a weigh-bridge conveniently placed on the cross line between the sheds. The passenger-shed will hold six carriages on one line of way.

There is a shed for repairing two carriages at a time. The locomotive engine-shed will hold two engines and tenders on a single line of way: it is furnished with a race or pit. There is a small office constructed of wood at this station.

The Haltwhistle intermediate station, as well as that of Hexham, is very properly railed in, which should also be effected at every other station on

this line, to prevent fraud, which is frequently committed by unprincipled persons on this railway. There is a water-column at each end of the Halt-whistle station, and a carriage-wharf conveniently placed.

The Wylam station-house is of neat rustic design; and, as the others on this line, is removed back to too great a distance from the rails.

At the Milton station, besides the booking-office and collectors' private rooms, there is a smithy with one hearth, a stable for one horse, a carriage-landing, and a large goods-shed. The station-house is about 34 feet by 22 feet, and has a small garden attached to it. The whole width of ground between the station-house and the tank-building, which is immediately opposite, is about $31\frac{1}{2}$ feet.

The tank, supported on brick arches, is constructed of cast-iron plates bolted together by means of flanches in the usual way, and is 20 feet 6 inches long, 5 feet wide, and 4 feet high. In front of the tank, and over the middle archway, is an iron pipe 8 feet long, with a hose at the end, to supply the locomotives with water. Being movable on a centre as a crane, the hose is readily brought over the tender-cistern; and by means of a long handle fixed over the pipe, the valve for opening and shutting the communication is easily regulated by the engine-driver or his assistant. In order to prevent the water freezing in frosty weather, a small copper is set in the middle archway, from which two 3-inch cast-iron pipes lead the steam into the tank above.

From Milton station to Brampton there is a single branch railway, on which passengers are conveyed in a carriage drawn by one horse.

At the Hexham station there are two main lines of way and two sidings. Covering three of the ways are four spans of roof supported on light cast-iron columns.

The station-building, which is of rustic design, is on a level with the rails, and detached from the sheds. These defects are exhibited in all the stations along this line; passengers having to pass from the carriages to the station-house are exposed to every kind of weather.

There is a capacious tank attached to this station, and fixed on a neat arched erection.

Close to this station, there being a level road-crossing, gates are fixed up, which shut both across the road and also across the railway, as required.

CARRIAGES. — There are three kinds of carriages used on this line, viz. first class, mixed, and second class. The first class are fitted up with every regard to ease and comfort, having spring-seats, and being lined and stuffed throughout. The glass sashes of the modern carriages are entirely free from the chattering noise so annoying in most railway-carriages. This improvement should be introduced into all first-class railway-carriages. We have repeatedly heard persons complain of the noise caused by the shaking of the glasses. A perforated iron footboard is fixed on each side of the carriage for its whole length. The first-class carriages are in three compartments, and hold each 18 passengers. The mixed carriages have the middle compartment fitted up for first-class passengers, and the other two compartments for second-class passengers. These will hold 22 passengers each. The second-class are open at the sides, and will hold 24 passengers.

On our view of this railway, in the latter part of 1839, the stock of carriages and wagons, &c. consisted of the following:—Twelve first-class carriages, each mounted on four $3\frac{1}{2}$ -feet wheels, and weighing altogether 3 tons 11 cwt.; six mixed carriages, each weighing 3 tons 3 cwt., and also mounted on four $3\frac{1}{2}$ -feet wheels; twelve second-class carriages, each weighing 2 tons 15 cwt., and mounted on four $3\frac{1}{2}$ -feet wheels; 220 goods-trucks, each weighing 2 tons 2 cwt., and having four 3-feet wheels; 56 ballast-wagons, each weighing 2 tons, the wheels being of 3 feet diameter; 36 cattle-trucks, the average weight of each being 2 tons 13 cwt. 2 qr., with 3-feet wheels; nine double sheep-trucks, each weighing 2 tons 17 cwt. 2 qrs., the wheels being of 3 feet diameter; 570 coal chalders-wagons, each weighing 1 ton 12 cwt., with 3-feet wheels.

Besides these, there are some luggage-coaches with seats above, similar to those on the Stockton and Darlington line, each weighing 2 tons 14 cwt.; the carriage-trucks weigh each 1 ton 17 cwt. 2 qrs.; the horse-boxes, 2 tons 16 cwt. 2 qrs., and having $3\frac{1}{2}$ -feet wheels; and others with 3-feet wheels, and weighing each 2 tons 10 cwt. The mails weigh each 3 tons 6 cwt. 2 qrs., and are mounted on four $3\frac{1}{2}$ -feet wheels.

The first-class carriages are painted yellow and picked out with black; and the second-class are painted white and picked out with green. The luggage-carriages and horse-boxes are painted green.

Some of the trucks used on this line are constructed of iron and wood

combined; having iron plates over the soles, which are cast with sockets to receive the joists or cross-timbers. A goods-truck, which is 10 feet 6 inches long and 7 feet 1 inch wide, with brake, springs, and coupling-chains, and having Hawks's wheels, costs 50*l*. On thronged days movable seats are set in the goods-trucks, so that almost any number of passengers may be accommodated. A set of these seats is worth about 5*l*. This arrangement is also adopted on the Brandling and North Shields Railways.

The coal-wagons are built much in the usual form, being of larger dimensions at top than at bottom, their capacity being equal to 53 cwt., which is the imperial chaldron. They are furnished with cast-iron wheels 37 inches in diameter, having inside bearings. Each wagon is provided with a double brake. Some of the coal-wagons have an iron skeleton frame and wooden linings. The coal-wagons are hired by the Company at a fixed sum per annum, and sub-let to the parties using them.

The trucks are built chiefly by Messrs. Rayner and Burn, of Busy Cottage, Newcastle, whose excellent workmanship has obtained for them a considerable share of the business on this and other railways in the neighbourhood.

At the stations, where coke is usually taken in for the locomotives, we observed small wooden-roofed boxes on four wheels, in which the coke is readily conveyed from one part of the station to another.

The cattle-trucks are 13 feet long, 6 feet 4 inches wide, and 4 feet high. Each end is furnished with a close boarded flap to let down. The sides are formed of uprights, 2½ inches square, let into iron sockets fixed on the outer side of each sole. Between these uprights are six narrow rails; and at the bottom a protecting board 10 inches high and 1½ inches thick. The wheels have outside bearings. The soles are 8 inches deep by 3½ thick, having at each end a false sole to form a solid buffer, which are thus made 14 inches deep.

The horse-boxes are built to hold two horses each; they are of wooden construction, and are 9 feet 9 inches long, 6 feet 4 inches wide, and 7 feet 2 inches high. At one end is a flap, which, being hung at the bottom, lets down to form an inclined plane for the horses to pass into or out of the box. The wheels are fixed 4 feet 7½ inches from centre to centre of axles.

The mail-guards on this railway are, as they should be on all railways, well protected against bad weather. The mails are entirely fitted for the con-

veyance of the bags and the guard only. The whole length of the body is 13 feet 6 inches, and the height above the soles 4 feet, except the guard's compartment, which is about 6 feet high, and of the same width as the rest of the body, and one fourth the length. It is entered by a glass sliding door in front, and has on each side a small window to give additional light, and to enable the guard to have a good view of what is going on without. The letter-compartment is furnished with three sliding doors on one side. A foot-board is fixed for the whole length of the carriage, and at a height of 1 foot 5½ inches above the rails. The wheels are 4 feet 7½ inches apart from the centre of one axle to that of the other.

At stations where there is no proper carriage-landing, a movable inclined plane is used for raising or lowering the carriages to or from the trucks.

LOCOMOTIVE ENGINE-DEPARTMENT.—The locomotives* are chiefly kept at Carlisle, Greenhead, and Blaydon. At Greenhead there are usually four engines stationed, this being the place where the engines leading the second-class trains are universally changed. We see no reason why this plan might not be adopted for the quick trains also. Sixty miles is evidently too great a length for one engine to travel without undergoing examination. The engine intended to proceed with the train on the journey might always have the steam up in readiness for the arrival of the trains at that station.

A four-wheeled engine on this line measures 15 feet in length by 6 feet 4 inches in width. The wheels are 4 feet 8 inches from centre to centre of axles; each of which has 14 spokes, and is furnished with a brass splasher fixed over it. The springs are fixed over the soles, and are 28 inches long. All the engines have ploughs in front of the fore-wheels, to clear the snow and other impediments which may present themselves. Four-wheeled engines are best suited for passenger-trains on this line, on account of its numerous curves.

The usual working pressure of the engines is 50 lbs. on the square inch. The engine-drivers use a rod to clear the ends of the tubes, which get choked up with clinkers, and thus prevent the full amount of communicative heat passing through the tubes. The fire-door is furnished with a chain, so that

* See Table XIX. of British Locomotives, in the Appendix.

the engine-man can open the door while the stoker is charging the fire-box with coke. Each tender holds about 18 sacks of coke.

The first 4-wheeled locomotive engine used on this line cost 1,000*l.*, including tender. The present price, including tender, for 6-wheeled engines, is 1,700*l.*

COKE-OVENS.—Until October 1839 the Company purchased all the coke used on their line; but having discovered that a considerable profit is attached to the manufacture of coke for sale, wisely determined to turn this profit to their own account. Twenty ovens were accordingly erected at Downhalf, by Tyne-side, on the branch-railway from Blaydon to Redheugh.

The ovens are arranged in one line, with a cooling floor in front paved for a space of five feet with bricks, and the remainder with stone flags. Between the back of the ovens (where they are charged with coal by openings 2 feet 3 inches wide by 1 foot 9 inches high) and the river, is a 5-feet passage, which separates them from a range of cellars, each having a wooden flap hung next to the river, where the coals are admitted from the vessels, and are thence conveniently transferred into the ovens.

On the opposite side of the quadrangle, and next to the cooling floor, are twenty more cellars, 8 feet 3 inches in depth, to receive the coal from the railway-wagons above by means of flaps in their bottoms, and openings above the cellars. The arches are segmental, and of 9-inch brickwork; and the piers 2 bricks, or 18 inches, in thickness. There are also archways at either end, which complete the quadrangle; and a single way is laid all round, with a turn-table at each angle, and another on the siding which communicates with the railway.

The brickwork in front of the ovens is 1 foot 10 inches thick, and the ends $2\frac{1}{2}$ bricks thick. The height of the ovens to the springing of the segmental arched roofs, in which are four apertures, each 8 inches square, is 6 feet 9 inches; the arches are each 9 inches thick, of fire-bricks, with brick on edge above. The depth of the ovens is 14 feet 6 inches externally; the partition-walls are 18 inches each in thickness. The doors in front are 2 feet 8 inches wide, and 2 feet 6 inches high, being semicircular at top, and constructed with a cast-iron skeleton-frame, fitted in with four fire-bricks 3 inches thick. Each door is hung on an upright round iron, which

turns on a cross-bar of iron over the top of the door, and resting in a proper socket projecting from the brickwork at the bottom.

All the ovens are firmly secured with vertical and horizontal ties of round iron $1\frac{1}{2}$ inches diameter. An upright tie is introduced between each two of the ovens: there is also an iron tie running horizontally for the whole length.

The charge of coal for each oven is 76·25 cwt. at one time, which remains in the oven forty-eight hours.

The description of coal used is Heaton Main, which costs at the ovens about 7s. 6d. a chaldron (53 cwt.), including keel-dues. Six men are constantly employed at this establishment. We were informed that the value of each of these ovens complete is about 50l.

The common bricks used in the work cost 30s. per thousand; fire-bricks, 3l. per thousand; and the bricklayer and mason each earns 26s. a week.

The coke for the year 1839 amounted to 4,153l. 15s. 3d., or at the rate of 11l. 7s. 6·34d. per diem.

THE TRAINS, &c. — In the latter part of 1839 we found the average weight of the trains to amount to 55,589 lbs.; the stoppages to average each 2·05 minutes; and the average speed of the passenger-trains to be at the rate of 24·41 miles per hour (see Table M. of Results of Practical Experiments, in the Appendix). At the present time (November 1840) there are altogether five through-trains daily in each direction, two of which are mail-trains, and perform the whole distance between Newcastle and Carlisle in 3 hours and $3\frac{1}{4}$ hours respectively; one quick-train, which performs the distance in 3 hours; and three mixed trains, which stop at every station, if required, and occupy $3\frac{1}{4}$ hours, including stoppages. There is also a mixed train daily from Newcastle to Haydon Bridge. On Sundays there are two trains in each direction.

The first-class intermediate stopping-places are at Blaydon, Wylam, Stocksfield, Corbridge, Hexham, Haydon Bridge, Haltwhistle, Rose Hill, Milton, and Weatherall.

The fares for first-class passengers by the quick-trains are at the rate of 2·164d. per mile; and for second-class passengers by the same trains 1·672d. per mile. By the mixed trains the fares for first and second-class passengers are at the rates respectively of 1·967d. and 1·475d. per mile.

The amount received by the Company for the conveyance of the mails is at the rate of $1\frac{1}{4}d.$ per mile for each journey.

The tickets are taken from passengers as they alight from the carriages at their destination.

EDMONDSON'S TICKETING SYSTEM.—As the ticketing system invented by Mr. Edmondson was first introduced on this railway, it may be as well briefly to describe it in this place. Mr. Edmondson, whose inventions for the purpose of facilitating the operations in railway booking-offices are of a very ingenious and useful character, was a book-keeper at one of the intermediate stations of this railway, but is now in the employ of the Manchester and Leeds Railway Company. The ticketing apparatus consists of a wooden box divided into several compartments, according to the number of stations on the line, and the number of classes of carriages. The first-class stations have one row of compartments, and the second-class stations another row of compartments allotted to them; the one row being higher than the other by several inches. On the front of each compartment the name of the station is affixed. The compartments are each about $2\frac{1}{4}$ inches square, and are furnished with a cover on the top hung with hinges. A certain number of tickets, which correspond in size with the compartments, are put into each at the beginning of the week; and are kept close together by a spiral-wire spring fixed at the bottom of the box, so that the edges of the upper ticket, except in front, are always pressed close under the ledges between each compartment. The ticket-collector applying his thumb to the upper ticket, quickly delivers it to the passenger applying for it. The tickets being numbered consecutively from the top, enables the collector to ascertain at any time the number of tickets which have been disposed of since the box was replenished; and each ticket-collector is accountable for so many first-class and so many second-class tickets as have been delivered to him at the beginning of the week. When not in use, the box is closed by a sloping cover, which keeps it from the dust.

This plan is now used, with considerable improvements, on the Manchester and Leeds and Blackwall Railways; and we hope, ere long, to see it introduced on every railway in the kingdom.

TRAFFIC, REVENUE, &c.—In the first five months of 1838, the line being opened for a distance of only $47\frac{1}{2}$ miles, the number of passengers conveyed by the trains amounted to 75,687, or at the rate, on an average, of 521·24 per diem. During the remainder of that year, the number of passengers conveyed on the line amounted to 117,364, or at the rate of 548·43 per diem. The total number of passengers conveyed by the trains in the year 1839 amounted to 236,258, giving an average of 645·59 per diem.

The second-class passengers conveyed by the mixed trains in proportion to those of the same class conveyed by the fast trains, were nearly as 3 to 1; and in proportion to the first-class passengers by the mixed and fast trains nearly as 20 to 1.

The gross receipts for the conveyance of passengers in the year 1837 amounted to 19,543*l.* 3*s.* 2*d.*; and for goods to 25,619*l.* 8*s.* 10*d.* In 1838 the amount received for passengers was 24,398*l.* 10*s.* 8*d.*; and for goods 35,103*l.* 19*s.*; and for 1839, 29,948*l.* 6*s.* for passengers, and 51,684*l.* 4*s.* 8*d.* for goods.

Taking these sums together, the average receipts per day would be at the rate of 67*l.* 9*s.* 7·07*d.* for passengers, and for goods 102*l.* 13*s.* 1·28*d.*

The gross receipts for passengers and goods during the above period amounted to 186,297*l.* 12*s.* 4*d.*, and the disbursements to 84,623*l.* 7*s.* 2*d.*; being at the rate of only 45·42*l.* per cent on the gross revenue.

The profit during the three years as above amounted to 108,316*l.* 6*s.* 11*d.*, from which should be deducted the interest paid on the Exchequer, and on various other loans; which, for one year only, ending the 31st December, 1839, amounted together to 19,617*l.* 10*s.*

The whole cost of working the railway for the year 1839 amounted to 37,234*l.* 10*s.* 11*d.*; of which repairs and materials of various kinds amounted to 3,679*l.* 6*s.* 4*d.*; salaries to 2,344*l.* 12*s.* 10*d.*; wages of waymen to 8,969*l.* 18*s.* 9*d.*; wages of porters and labourers at depôts to 5,256*l.* 7*s.* 2*d.*; wages of guards to 581*l.* 6*s.* 6*d.*; wages of engine-drivers and firemen to 2,510*l.* 5*s.* 7*d.*; wages of engine-wrights, smiths, strikers, and other mechanics, to 2,494*l.* 7*s.* 8*d.*; coke to 4,153*l.* 18*s.* 3*d.*; poor-rates to 1,190*l.* 7*s.* 11*d.*; duty on passengers to 2,235*l.* 14*s.* 9*d.*; incidental and travelling-expenses to 2,205*l.* 13*s.* 7*d.*; and road-coaches, tolls, steam-boats, &c. to 1,013*l.* 17*s.* 4*d.*

Thus the salaries and wages together amounted to nearly six-ninths of the whole outlay; the coke to about one-ninth; and the remaining items of duty, incidental expenses, &c. to two-ninths.

NEWCASTLE AND NORTH SHIELDS RAILWAY.

NEWCASTLE, the northern metropolis of England, is justly celebrated as the birth-place of several individuals distinguished for the improvements they have effected in the mechanical arts. It is also worthy of particular notice, as being the first place where locomotive engines were constructed on an extensive scale. In the neighbourhood of Newcastle, wagon-ways, constructed of wood, for the use of the collieries, have been in use for a very long period; and here, too, the first experiments on adhesion, for the purposes of railway-locomotion, are said to have been tried. At the present time, Newcastle can boast of three important railways terminating in its suburbs. Of these the Newcastle and North Shields Railway is deserving of peculiar notice, and presents as great an amount of skill in the construction of its works as any other line of equal length in the kingdom. The credit of this work is jointly due to Mr. Robert Nicholson, the engineer, and Mr. Green, the architect of the Company, both residing in Newcastle; the former for the engineering works generally, and the latter for the design and construction of the two celebrated laminating wooden bridges, the former spanning over the Ouse Burn, and the latter over Willington Dean.

The original survey for this line was made by Mr. Nicholson in 1835; and, in addition to the main line to North Shields, an extension to Tyne-mouth was intended, and also a branch to the river Tyne, at North Shields; neither of which have, however, been carried into effect.

COURSE OF THE LINE.—The main line presents very little alteration in its course from that originally laid down. The present terminus at Newcastle is about 176 yards to the east of the intended station in Pilgrim Street, from

whence the line takes a course nearly east, through the townships of All Saints, Heaton, Walker, Wallsend, Willington, and Chirton. In its course it passes near to several collieries; among others may be mentioned that of Wallsend, so long known, and from which so much excellent coal is sent to the London market.

CURVES.—This line is quite free from objectionable curves; the shortest radius of curvature being of one mile, near the North Shields terminus.

The inclinations, commencing at Newcastle, are as follow :—

Lengths of Planes.		Ratio of inclination.		
Miles.	Chains.			
	33·00	descending	at the rate of	1 in 442
	71·00	ascending	„	1 in 200
1	66·00	descending	„	1 in 352
	70·60	descending	„	1 in 183
1	07·40	ascending	„	1 in 180
	40·00	ascending	„	1 in 322
	13·10	ascending	„	1 in 994
1	18·10	descending	„	1 in 264
6	<u>79·20</u>			

The whole length of the line, therefore, is 6 miles 79·20 chains. The part at present finished, however, and opened to the public, is only about 6½ miles long. The gradients, it will be seen, belong to the second class.

EARTHWORKS.—The cost of the cuttings averaged about 9*d.* a cubic yard. Close to the temporary station at Newcastle there is a short embankment, 80 feet at its greatest height.

The cutting in Heaton township, which is about 25 feet at its greatest depth, and nearly a mile in length, presented considerable difficulties during its execution; a considerable amount of quicksand having to be removed, and a continual overflow of water occurring, rendered it a very troublesome undertaking. Mr. Straker, who had been engaged on this work, proposed that the water should be got rid of by boring down into the old coal-workings; but Mr. Nicholson considered that it would be better to carry a large

rubble-drain at about 8 feet below the cutting, and this was found to answer the purpose exceedingly well.

The slopes of cuttings through unstratified clay are $1\frac{1}{2}$ to 1, and where stratified, 2 to $3\frac{1}{2}$ to 1. The slopes are sown with grass-seeds. The embankments have slopes of from $1\frac{1}{2}$ to $2\frac{1}{2}$ to 1. Some of them are made of small coal and refuse from old pit spoil-banks, to the extent altogether of 150,000 cubic yards.

BRIDGES, &c.—On our view of this line we counted about seven bridges over, and twenty-eight under the railway. The Ouse Burn and Willington Dean viaducts are particularly worthy of notice, as presenting a novel feature in the bridge-building of this country.

That over the Ouse Burn has five arches of wood, each of 116 feet span, and two of stone, each of 45 feet span, and is altogether 920 feet in length, and 108 feet high above the burn. The piers and abutments are of stone. Each of the wooden arches is composed of three ribs turned to the requisite form, and consists of 15 three-inch deck deals, from 20 to 45 feet in length, and two deals in width, so put together as completely to break joint throughout.

The alternate courses are formed of two whole deals, and one whole and two half deals respectively. Between each course is placed a thickness of brown paper dipped in boiling tar; and the various courses are secured together by oak trenails, each of which passes through three deals in thickness. The end of each rib is fitted into a cast-iron socket let in and secured to the masonry with long iron bolts, four to each plate; and the three ribs are connected crosswise by diagonal braces and iron bolts.

The spandrils are also formed of timber; each spandril is divided in the direction of its height by a piece of timber 14 inches square, which inclines upwards towards the crown of the arch. Above the ribs are radiating struts, which run up to meet the dividing timber; and above this are vertical struts running up to the longitudinal timbers of the road-way. One of the radiating timbers of each spandril is continued till it meets the longitudinal beam above it, and is firmly connected therewith, and also with the masonry, by bolts, which run down into the piers and abutments about 8 feet. The longitudinal road-timbers are 14 inches square; and the joists, placed transversely, are

3½ feet apart. These project over the sides of the outer ribs to receive the 3-inch planking, which forms a footway on either side of the railway. A stout wooden balustrade running from end to end, five rails in height, serves on each side for a parapet. A wooden fender, 9 inches by 6 inches, is placed on the outside of each of the external rails, as a check for the locomotives in case of their getting off the line.

Mr. Green very justly observes, that in this system of timber bridge-building the spandril-framing "is merely a continuation of wood-work to carry the weight coming upon the roadway on to the simple curved rib; and all timbers in a state of tension are avoided, for when a weight comes upon the roadway, the whole structure undergoes compression."

All the timbers have been kyanized; but with what success in regard to preserving this bridge beyond the ordinary duration of timber so exposed to the weather, yet remains to be proved.

The Willington Dean viaduct, which is of similar construction, is 1050 feet in length, and 82 feet in height, with seven wooden arches, each of 120 feet span. In founding several of the piers it was found necessary, in the first place, to drive piles about 35 feet long and 3 feet thick into the clay.

With regard to cost, it appears that from an estimate made by Mr. Green, a saving in these two viaducts was effected of more than 14,000*l.* by substituting wood for stone. Yet it must be remembered, that with the 14,000*l.* additional, the first cost would have been also the last; whereas with the timber no estimate of its duration can at present be made with any degree of certainty. The cost of each of these viaducts is stated to be about 24,000*l.*

There are two laminating wood bridges, carrying the railway over public roads, the construction of which is similar to that of the cast-iron tie-bridges used on the Birmingham and Manchester and Leeds Railways. The platform is suspended from the arch on either side by truss-work from side to side. The skew-span of one of these bridges is 71 feet; the angle 25°; and the ribs are of 7-inch planks, put together as those used in the viaducts above described. The other bridge of similar construction is over the branch turnpike-road to North Shields, and is 52½ feet in skew-span, being built at an angle of 25°. The width between these ribs in each case is 21 feet 10 inches.

The bridges over the railway are 22 feet 6 inches in clear span, and

16 feet high, chiefly constructed of free-stone from various quarries, particularly from Byker Hill; and for the bridges in the eastern division of the railway, from Billy Hill, near Shields.

Mr. Nicholson states the cost of a turnpike-road bridge on this railway, of the clear height of 16 feet, to be about 1,000*l*.

The clear width between the parapets of bridges carrying the railway over roads, &c., is 24 feet.

About a quarter of a mile from the present Newcastle terminus there is a short tunnel, about 103 yards in length, 16 feet 6 inches high, and 22 feet 6 inches in span, which was executed by open cutting. The walls are 6 feet in thickness, and constructed of stone; and the arch of brickwork 18 inches in thickness. The cost of this work was about 16*l*. 10*s*. per lineal yard.

All the abutments of bridges have a batter of $\frac{1}{4}$ inch to the foot.

There are three turnpike-roads crossed on a level by the railway, at each of which there is a lodge and gates, and a man in constant attendance. The gates are furnished with a red disc in the middle, according to the usual plan. There is also a private road-crossing on the level, as well as a colliery-way.

GAUGE, RAILS, &c.—The gauge of way is 4 feet 8 $\frac{1}{2}$ inches; and the intermediate space 5 feet 5 inches wide. The whole is a double way, with a traverse or crossing at each terminal station, and also one about half-way.

The rails are of the broad-based T-form (see Plate 3, fig. 50), and weigh 54 $\frac{1}{2}$ lbs. per lineal yard. They were rolled at the works of Messrs. Losh, Wilson, and Bell, of Walker, and cost about 10*l*. 10*s*. per ton. They are laid on longitudinal bearers of Dantzic timber, all kyanized, and secured thereto by screw-bolts, $\frac{1}{2}$ -inch diameter and 6 inches long, furnished by Ryland of Birmingham, at 56*s*. a cwt.: a gross of these screws weighs 88 lbs. The perforations in the base of each rail are bored at right angles to the upper surface. To each 15-foot rail there are generally 11 bolts, but some have 13 bolts to a rail. The rails are seated on Borradaile's patent felt, which costs at the rate of 6*s*. 6*d*. per 100 feet.

The longitudinal timbers, in lengths of from 20 to 50 feet, are of Memel or Dantzic, 12 inches by 6 inches, halved and bolted together at joints, and resting on cross sleepers, also 12 inches by 6 inches, and 6 feet apart. Trans-

verse ties of old oak, 5 inches by 3 inches, and 8 feet from middle to middle, are dovetailed into the longitudinal timbers, and secured thereto by oak trenails. Under the cross ties is left a clear space of about half an inch, to allow for their settlement at the same time with that of the longitudinal timbers.

The longitudinal timbers, which are of the description called "best middling," cost 14½*d.* per foot lineal, and the oak-ties from 14*d.* to 16*d.* each. The tanks used for kyanizing the fir-timbers are three in number, two being 68 feet in length, 5 feet wide, and 5 feet deep; and the third being 90 feet long, and 6 feet wide by 5 feet deep. They are all fixed on dwarf-walls, to keep them above the surface of the ground. The timber is under the solution for seven days, and the cost of kyanizing is estimated at 3*d.* per cubic foot. The 90-feet tank cost 200*l.*, and the foundation-walls about 15*l.* 10*s.*

The ballasting consists of broken stone, cinders, small coals, and brick-rubbish.

The open drains vary in size, according to the nature of the ground and extent of slopes; besides these, rubble-drains are used in some of the cuttings.

The fencing consists of posts and two rails of larch, which are placed outside the ditch, between which and the Railway is the open drain.

The whole width of land, from fence to fence, is 42 feet 6 inches. The area of land taken is equal to about 55 acres; and the cost of the land near Newcastle was from 4*s.* to 12*s.* a square yard; and along the line from 100*l.* to 300*l.* an acre, including severance. Next to grass-lands the fencing has three rails. The two-rail fencing costs 3*s.* 9½*d.* per rood (7 yards), and the quicks about 13*s.* 6*d.* per 1000, each rood taking from 25 to 30 plants.

STATIONS.—There are four stopping-places, besides the terminal stations of Newcastle and North Shields.

The first intermediate station is at Walker, and is on a level with a cross-road at the point of crossing; the second is at Walls End, on a 5-feet embankment; the third in Willington Township, in a 5-feet cutting; and the last at Percy Main, on a 7-feet embankment.

The Newcastle station, which is merely temporary, consists of a booking-office and waiting-room, with a stone platform round two sides and end, and 2 feet 3 inches above the level of the rails. There are only two lines of way at

this station, which terminate each on an engine-turning platform of 13 feet 8 inches diameter, and 14 feet 2 inches from the centre of the one to that of the other. The intermediate space is increased as each way approaches its respective turn-table. The turn-tables were built by the Company, at a cost of 30*l.* each. The platforms are of 3-inch plank.

This station is lighted at night by seven gas-burners. Mr. Nicholson has suggested a plan of lighting the whole of the Railway by gas drawn from the coal-pits, which, if it can be carried into effect, will present a novel feature in railways.

The front of the offices of the South Shields station is next to Little Bedford Street, extending 60 feet in length by 29 feet in depth. The double way is continued quite up to and under the offices, terminating on each side on a turn-table, as at the Newcastle station. There is a booking-office and waiting-rooms, for first and second-class passengers, and water-closets and urinals attached. From the offices are two flights of steps 10 feet wide, and rising each 6 inches, leading down to the platforms, one to either side of the passenger-shed. The platforms of this station are 16 feet and 18 feet wide respectively. The whole length of this station is 570 feet. On each side of the main lines there is a siding; that on the right running in front of the goods-shed (which is 70 feet in length and 30 feet deep); and also being continued up to the inclined carriage-landing, which has a rise of 1 in 21 to the arrival-platform. The other siding runs through the carriage-shed, which is 100 feet in length and 15 feet in width. This station is in 16-feet cutting. The whole area is about two acres.

CARRIAGES.—The stock of carriages consists of eight first class, four of which were purchased of the Liverpool and Manchester Railway Company, at 265*l.* each, exclusive of wheels; two mails in three compartments, each holding six passengers; and fourteen second class, also in three compartments, and which are open at the sides, each compartment holding eight persons; there are also eight passenger luggage-trucks, one of which accompanies each passenger-train. The mails, including Losh's wheels (34*l.* a set), each cost 394*l.* The best carriages are painted lake, picked out with black. The first-class carriages are much the same as those of the Grand Junction Railway, and were built by Messrs. Atkinson of Newcastle. The second-class carriages

are each 14 feet 7 inches in length, fixed on a double buffer and drag-spring frame; and furnished with Atkinson's springs, 5 feet in length, which consist each of 15 steel plates. The seats are 12 inches wide, 17 inches apart, and 19 inches above the floor. An iron-plate footboard runs along each side for the whole length.

We observed the inside of the second-class carriages to present as dirty an appearance as those of the Greenwich Railway, shewing the description of persons who are glad to avail themselves of railway-conveyance.

Some of the second-class carriages hold only 20 passengers, having two whole and one half-compartment.

On the panels of the first-class carriages the fare "1s." is distinctly marked; and on the second-class carriages "6d." is also marked.

The short tunnel near Newcastle, being furnished with gates at either end, serves for a carriage-shed at night.

At each of the terminal stations the following words are painted in conspicuous letters:—"The next train will leave at o'clock." The tickets are taken at starting. The trains depart from either end of the line twenty times a day, and on Sundays eighteen times from Newcastle, and seventeen times from North Shields. The line was opened to the public on the 22d June, 1839. During twelve weeks ending 13th Sept. 1839, the number of passengers conveyed on the line was 178,215, or on an average at the rate of 2121·60 per diem. During the latter six months of 1839, the number of passengers conveyed by the trains amounted to 337,110, or at the rate of 1847·17 per diem. The proportion of second to first-class passengers was nearly as 10 to 1; and of first-class to mail-passengers nearly as 30 to 1. The receipts for passengers during the same period amounted to 9150*l.* 4*s.* 9*d.*, or at the average rate of 50*l.* 2*s.* 9·12*d.* per diem. The fare for a first-class passenger is at the rate of 1·777*d.*, and for a second-class passenger ·888*d.* per mile respectively.

LOCOMOTIVE DEPARTMENT.—The locomotive engines used on this line are from two of the first establishments of the kind in the kingdom, viz. those of Messrs. R. Stephenson and Co. and Messrs. Hawthorn, both of Newcastle. The proportions of each engine will be seen by reference to Table XX. of British Locomotives, in the Appendix. The usual working pressure is from 50 to 55 lbs. on the square inch.

The trains consist of from six to ten carriages and one luggage-truck. The average time of performing the single trip is 21 minutes. The tenders carry each 650 gallons of water.

The coke used is from Wylam; the cost of the Wylam coal is 10*s.* per imperial chaldron (53 cwt.). The consumption of coke amounts to about 2576 lbs. for five double trips, or 67 miles; and the weight of an average train being taken at 40 tons, the consumption of coke is equal to 961 lb. per ton per mile.

Each engine is laid by every third day, to be thoroughly cleaned, examined, and repaired if necessary.

THE ESTABLISHMENT.—The establishment, in the autumn of 1839, consisted of one secretary, one engineer, two booking-clerks at the Newcastle station, and two at the Shields station, and four collectors at the intermediate stations, whose salaries were each at the rate of 60*l.* a year; one engine-inspector, who earns 5*s.* a day; three engine-drivers, each at 4*s.* a day; three firemen and two cleaners, each at 3*s.* a day; one police-inspector, at 30*s.* a week; twelve police, each at 17*s.* a week; three guards, two brakemen, five porters at the Newcastle station, and six at that of Shields, and four station-men at Newcastle, at 3*s.* a day each, respectively; and two carriage-cleaners, each at 2*s.* 8*d.* a day; altogether fifty-two persons, exclusive of waymen.

ACTS OF PARLIAMENT, COST, REVENUE, &c.—The Act of incorporation received the royal assent on the 21st June, 1836, and authorised the Company to raise a joint-stock capital of 120,000*l.*, in 2400 shares of 50*l.* each, and by loan an additional sum of 40,000*l.* A second Act was obtained in the session of 1840, which received the royal assent on the 19th May, and empowered the Company to raise a further sum of 160,000*l.*

The cost of the railway, up to April 1840, amounted to 240,000*l.*, or at the rate of 36,363*l.* 12*s.* 8*d.* per mile; being double the amount of the original capital.

The gross receipts from the 22d June to the 31st December, 1840, amounted to 10,001*l.* 6*s.* 2*d.*; and the disbursements for the same period, to 4,794*l.* 10*s.* 5*d.*, which is equal to 47·93*l.* per cent on the gross revenue.

The locomotive power for the above period amounted to 1,199*l.* 2*s.* 4*d.*; repairs to carriages, &c. 159*l.* 3*s.* 4*d.*; wages of guards, police, way-men, and station-men, 1,232*l.* 1*s.* 10*d.*; passenger-duty, 1,144*l.* 18*s.*; superintendence, clerks, printing and advertising, 656*l.* 7*s.* 4*d.*; gas, coals, candles, and incidental expenses, 87*l.* 3*s.* 1*d.* In the goods-department, clerks, porters, and delivery of goods, 229*l.* 10*s.*; and printing and advertising, 28*l.*

NORTHERN AND EASTERN RAILWAY.

THE most direct course for a railway between the metropolis and York is evidently that which was taken by the Northern and Eastern Railway Company, running by Cambridge, Peterborough, and Lincoln, and surveyed under the direction of Messrs. Walker and Burges in 1836; the whole distance from London to York by that route being only 194 miles, or about 22 miles shorter than by the present line of railway-communication. The Northern and Eastern Railway has, however, now dwindled into a Stratford and Bishop Stortford line, although still retaining its original title. It is much to be regretted that the complete design had not been carried into effect: we hope, however, yet to see this desirable object effectually accomplished, and that within a very few years; for we are not acquainted with any projected railway in the kingdom that would be so likely to repay its proprietors so well as the direct and easy line between London and York, if carried out according to a rational system of construction.

ACTS OF PARLIAMENT, &c.—The Act for the incorporation of this Company received the royal assent on the 4th July, 1836, and authorised a capital in joint stock to be raised of 1,200,000*l.*, and by loan 400,000*l.* additional. In the session of 1839 two Acts were passed, both of which received the royal assent on the 19th of July; the first was for the purpose of extending the time for the purchase of the land as far as Bishop Stortford; and the second was chiefly for confirming an agreement with the Eastern Counties Railway Company as to the terms, &c. for passing over that line.

By the Company's last Act, which received the royal assent on the 4th June, 1840, the joint-stock capital was reduced to 720,000*l.*; and the Company obtained power to raise 240,000*l.* on debentures, so soon as one moiety of the capital should be paid up. And by the same Act, that portion of the line between Bishop Stortford and Cambridge was entirely abandoned.

GENERAL COURSE OF THE LINE.—Leaving the Eastern Counties Railway near Stratford, with a curve of 51 chains radius, and at a distance from Shoreditch of $3\frac{1}{2}$ miles, the line proceeds in a north-western direction, through the parishes of Low Leyton and Walthamstow, crossing the Epping road at a distance from Lea Bridge of about half a mile, and passing midway between the river Lea and the Copper Mills in Walthamstow parish; thence, with a curve of about 100 chains radius, falling into the original line about 15 chains to the west of Tottenham Mills, from whence the line runs nearly in a northern direction as far as Wormley, keeping altogether to the east of the Old York Road; from Wormley, with a curve of about two miles radius, it falls into a direction a little to the north of east, passing through Roydon and by Little Parndon, and running to the south of the Stort river to near Sawbridge-worth, where it crosses that river, and continues in a slightly curving course to its termination near Bishop Stortford and Hockerhill. The length of the line from the Stratford junction being $28\frac{1}{2}$ miles, and the entire distance from Shoreditch $32\frac{1}{2}$ miles.

INCLINATIONS.—Leaving the Eastern Counties Railway, the line descends for a length of 34 chains, with an inclination of 1 in 379; a level plane succeeds, extending to the Lea Bridge, or Epping Road, a distance of 1 mile 79 chains; the next is an ascending plane for $1\frac{1}{2}$ miles in length, and rising at the rate of 1 in 700; thence follows a second level plane of 36 chains in length, which brings the line up to Tottenham Mills Road. From this point the remaining portion of the line is altogether ascending, being divided into six planes, the respective lengths and inclinations of which are as follows, viz.:—5 miles 58 chains, 1 in 1079; 2 miles 25 chains, 1 in 1526; 11 miles 37 chains, 1 in 665; 1 mile, 1 in 330; 1 mile 64 chains, 1 in 16,292; and 2 miles 7 chains, 1 in 330. This line, therefore, comes under the first class

in point of gradients; the whole rise from the Eastern Counties Railway at Stratford being 183 feet 4·80 inches.

EARTHWORKS, &c.—In point of earthworks we are not acquainted with a more favourable line in the kingdom than that at present under consideration; excepting, of course, those which are carried entirely on arches. From the Stratford junction, for a distance of upwards of sixteen miles, to Broxbourne, the railway is elevated but a few feet above the general surface of the lands; beyond this point, where it crosses the valley of the Lea, and enters an undulating country, the line alternates in cutting and embankment. The chief works in this department are the Lea Valley embankment and the Roydon cutting: the former being about two miles in length, and averaging about 12 feet in height; and the latter about three quarters of a mile in length, and averaging about 16 feet in depth. The slight embankment from the Epping road to Broxbourne is chiefly formed from side-dykes, from which a great deal of gravel has been obtained for ballasting the way.

BRIDGES, &c.—The bridges, as is the case with all the brickwork and masonry throughout this line, are built in a very substantial manner. Between the Stratford junction and Broxbourne, a distance of $15\frac{1}{2}$ miles, we counted five bridges over the railway and twelve under, including two over the Lea River; besides fifteen large culverts.

The number of level road and lane-crossings we found to be twenty-four, and of occupation and field-crossings twenty. At each of the principal level road-crossings a lodge is erected, with strong and well-proportioned wooden gates (see Plate 16, fig. 17), which shut either across the railway or road as required.

The bridge which carries the Epping road over the railway is of 24 feet 4 inches span and 17 feet high to the springing line of the segmental arch, and of the whole width of the turnpike-road over it. The arch is constructed of brickwork, springing from cast-iron plates, which are connected together by wrought-iron ties running from one abutment to the other.* This plan enables the engineer to introduce an arch with but very little rise, and at the

* We had a model made of this mode of construction about fifteen or sixteen years ago, which we have reason to think was the first time it had been suggested.

same time of great strength ; two points of considerable importance in the bridge-building department of railways.

In the Marshes, at each paved level crossing there is also a cattle-arch under the railway ; a plan successfully carried into effect on the Birmingham and Derby Railway.

GAUGE OF WAY, &c.—The gauge is 5 feet, the intermediate space 6 feet 5 inches, and each side-space 5 feet wide ; so that the top-width of embankment is 26 feet 5 inches, the width of each side-dyke in the neighbourhood of Lea Bridge is 7 feet, and the space between it and the fence 6 feet ; making the whole width of land enclosed equal to 52 feet 5 inches.

The rails are of the double parallel form (see Plate 3, fig. 50 *a*), in 12 and 15 feet lengths ; but the upper and lower webs are not of similar section, as is most generally the case, neither are the points of support arranged for equal intervals, the engineer having concentrated the greatest amount of support at the joints ; for instance, with a 12-foot rail the points of support at the meetings are only 2 feet 1½ inches apart, whereas the distance between each of the remaining intervals is 3 feet 10½ inches. This method is introduced on parts of the North Midland Railway also, and appears to us a decided improvement on the usual plan of equidistant points of support throughout. The ends of the rails by the new method are not so liable to be displaced ; a consideration of the utmost importance in effecting an even passage for the wheels of the engines and carriages.

The rails are set in chairs, with sockets formed as usual to receive the inner side of the rail. The joint-chairs are each 10 inches long and 5 inches wide ; and the intermediate chairs 10 inches long and 3 inches wide, the height of each description being 5 inches. The rails are secured to the chairs by uncompressed fir-keys 12 inches long, and having a transverse section of 2 inches by 1½ inch. The chairs are secured to sleepers throughout, with two spikes to each chair. The sleepers are of larch, each 9 feet in length, and measuring 10 inches by 5 inches.

The ballasting is of gravel, of at least 2 feet in thickness throughout.

This is altogether the most complete permanent way on the transverse system we have hitherto met with. The drains are of ample capacity to carry off the ordinary land-flood waters.

The fencing for a great proportion of the length between Stratford and Broxbourne is of a novel description, consisting of iron standards, at intervals of 6 feet, and six wires running horizontally, and passing through perforations in the standards, the wires being placed closer together as they approach the ground. Although it has a very neat appearance (see Plate 16, fig. 23), we question whether this kind of fencing will be found economical in the end. Unless occasionally coated with anticorrosive, or other equally effectual paint, the wires will soon have to be reinstated. Moreover, it will not answer for heavy cattle, which frequently delight in rubbing themselves against fences. Other parts of the line are enclosed with stout posts and four-cleft rails.

The mile-standards are fixed at intervals of a quarter of a mile, and are of wood, standing 3 feet 7 inches above the ground, and measuring 6 inches by 6 inches.

STATIONS. — At Shoreditch this Company is accommodated with part of the Eastern Counties station.

The intermediate stations already opened to the public are at the Lea Bridge Road, Tottenham, Edmonton, Enfield-Highway and Ponder's End, Waltham Cross, and Broxbourne.

The Lea Bridge station is situate at the bridge which carries the Epping road over the railway. The booking and other offices are contained in a building of handsome elevation, in the Italian style of architecture, over the bridge. There are likewise waiting-rooms under some of the road-arches. The communication to the passenger-platforms is by means of a flight of stone steps; each platform is paved with stone, and is 2 feet high above the level of the rails. The side-space at this station is 2 feet.

The buildings of the Broxbourne station are of red brick, in the Elizabethan style, forming altogether a quadrangle, with a shed over the platform of the down-line.

The most rational description of building for an intermediate station on this line is that of Edmonton, which contains but the offices actually required for the traffic of the line, and these all on one floor. It reminds us of the stations in Belgium, though of a rather more expensive character.

The present mode of erecting expensive buildings at every intermediate

station cannot be pursued much longer. If we would wish to introduce collateral lines of railway throughout the country, they must be executed altogether according to a less expensive plan, or many of the agricultural districts must for ever be debarred of the advantages of railway-communication.

CARRIAGES AND ENGINES. — The carriages on this line present a novelty in being mounted on six instead of four wheels, except those of the Great Western and Blackwall lines. One of the advantages of this mode of construction is, that the carriages are less likely to run off the line, or to give way by reason of an axle breaking on the journey.

The first-class carriages, which are in four compartments, will hold twenty-four passengers; the second class, also in four compartments, thirty-two passengers; and the Stanhopes an indefinite number. The first-class carriages are each 20 feet long and 7 feet wide; and the Stanhopes are also of the same dimensions, and are divided into four compartments simply by two bars crossing each other in the middle. The carriages are all furnished with improved springs 5 feet long from point to point. A bottom footboard runs the whole length, and on both sides of each carriage.

We can bear testimony to the ease and comfort of travelling in the first-class, and of the comparative ease of the second-class carriages, all of which, we understand, were built by Mr. Wright.

The locomotive engines are likewise all mounted on six wheels, and are from the works of first-rate makers.

The principal engine-station is near the Stratford junction. It is a brick building of polygonal form, having sixteen sides, and as many lines of way within radiating from a central turn-table. The diameter of this erection is 82 feet, and its height 37 feet. The roof, which is supported by the external walls and sixteen lofty iron columns, ranging round the turn-table at equal distances from the angles, is furnished with a capacious lantern in the centre by which the whole building is lighted. A lobby projects on the north-western side, which is furnished with a single line of way and an engine-race of full length. This line being produced effects a communication between the main double way and the engine-house.

FARES, TRAFFIC, &c.—The number of trains daily in each direction,

except on Sundays, between London and Broxbourne, is six, with an extra up-train on Monday mornings. On Sundays there are four down-trains, and three up.

The fare for first-class passengers for the whole distance of 19 miles is 3*s.* 6*d.*; for second-class passengers, 2*s.* 6*d.*; and for third-class passengers, 1*s.* 6*d.*; being at the rates of 2·210*d.*, 1·578*d.*, and ·946*d.* per mile respectively.

The line was opened to the public as far as Broxbourne on the 15th of September, 1840.

In six weeks, ending November 3, 1840, the number of passengers conveyed by the trains amounted to 32,819, being equal on an average to 781·40 per diem; and the receipts for passengers, &c. for the same period amounted to 2301*l.* 19*s.* 1½*d.*, or at the rate of 54*l.* 16*s.* 2·02*d.* per diem.

The rent to be paid by this Company for the use of part of the Eastern Counties London station is 7000*l.* a year, besides a toll of 4*d.* for each passenger passing over the 3½ miles between Shoreditch and the Stratford junction.

The following exhibits the various items of expenditure up to 30th June, 1840:—

Preliminary expenses and obtaining Acts of Parliament, &c.	£ 36,475	18	6
Lands and compensation	£ 91,797	11	5
Lands purchased on branch to Islington, now } abandoned }	36,735	8	0
		128,532	19 5
Engineering	7,541	19	3
Surveying and agents	11,271	18	1
		18,813	17 4
Law-expenses		6,289	15 8
Direction, up to 31st December, 1839*		4,050	0 0
Contracts	36,789	10	6
Materials	230	0	0
		37,019	10 6

* The directors, since the above date, have very liberally given their services gratuitously; an example worthy of imitation by those of other lines which are not as yet in a profitable condition.

Office-expenses, including furniture, salaries, rates and taxes, &c.	}	6,616	1	9	
Printing, stationery, &c.		589	19	4	
Miscellaneous		59	2	8	
					7,265 12 9
Loans paid off		30,300	0	0	
Interest on loans		748	16	11	
					31,048 16 11
					<u>£ 269,496 11 1</u>

Mr. Walker having resigned his appointment of engineer to the Company, the directors selected Mr. Robert Stephenson to be his successor, who, in September, 1839, reported that that part of the line lying between Tottenham Mills and Broxbourne was completed, except about half of the ballasting of the permanent way, that it had been executed at a cost little exceeding 3000*l.* per mile, and that on the remaining portion between Broxbourne and Bishop Stortford, there was no cutting to be excavated of a greater depth than 25 feet, nor embankment to be raised exceeding 12 feet in height; and with regard to the cost of the railway, exclusive of land, his estimate for a single line of way only was 280,000*l.*, and for engines, stations, carriages, and workshops, 90,000*l.*; together 370,000*l.*, or at the rate of 12,873*l.* 0*s.* 10·43*d.* per mile.

NORTH MIDLAND RAILWAY.

THE stations of the North Midland Railway have afforded Mr. Thompson, the architect, ample scope for the exercise of his talent, which is strikingly exhibited throughout the whole of the permanent buildings of this railway. But although highly estimating the elegantly chaste designs which characterise the architecture of the North Midland stations, we cannot but deplore the growing evil of expending large sums of money on railway appendages. Instead of cottage-buildings, which, for the traffic of most of the

intermediate stopping-places on this line, would have been amply sufficient, we find the railway literally ornamented with so many beautiful villas, any one of which would grace the sloping lawn of some domain by nature highly favoured.

But we must proceed to the immediate purpose of the present description, observing the same order we have generally adopted throughout this work.

ACTS OF PARLIAMENT, &c.—The royal assent was given to the Act of incorporation on the 4th July, 1836; it empowered the Company to raise a capital in joint-stock of 1,500,000*l.*, and by loan 500,000*l.* additional. In 1837 an amended Act was obtained, for the purpose chiefly of making certain diversions from the original line. In the session of 1839 a third Act was obtained, for making a deviation in the line towards Leeds, which is dated 1st July, and authorised the Company to raise an additional sum of 1,000,000*l.* Thus the whole amount which the Company is empowered to raise by shares and loans is 3,000,000*l.*

The number of original shares of 100*l.* each is 15,000; and of half-shares the same number. The sum received on account of the original shares, up to 30th June, 1840, amounted to 1,445,940*l.*; and on the new or half-shares, 370,023*l.* 12*s.* 6*d.* The loans raised, up to the same date, amounted to 867,730*l.*; and the interest for calls in arrear, cash in anticipation of calls, premiums on 50*l.* shares, materials resold, and rent of cottages, to 21,983*l.* 4*s.* 11*d.* Thus the whole amount received as above is 2,705,676*l.* 17*s.* 5*d.*

GENERAL COURSE OF THE LINE.—Leaving the trijunct-station at Derby, the line passes to the west of Holbrook, thence proceeds to Belper, North Wingfield, Clay Cross, and to the east of Chesterfield; beyond which it curves into a direction about north-east, and thence takes a recurving course to Eckington, from whence it is produced to Masborough, where a short branch diverges in a south-western direction to the Sheffield and Rotherham Railway. From Masborough the line bears in a direction about north-east to Swinton, which is the station for Doncaster, thence continues to the east of Barnsley, approaches Oakenshaw, and within two miles of Wakefield,

which is on the west, and is produced to Normanton, at which place the Manchester and Leeds Railway falls into this line. Beyond Normanton the York and North Midland Railway diverges in a north-eastern direction; the line is then traced in a curving and recurving course by Woodlesford to its termination at Hunslet Lane, Leeds.

The curves are generally of a mile radius.

INCLINATIONS.—In point of gradients this line, having inclinations of 1 in 264, or 20 feet in a mile, comes under the second class of railways. Leaving Derby, the first reach extends to the Derbyshire summit, a distance of 17·75 miles: it is divided into thirteen planes, ten of which are ascending, and vary in inclination from 1 in 330 to 1 in 5443, two descending at the rates respectively of 1 in 634 and 1 in 1760, and one level for ·80 mile; the whole height being 193 feet 4·80 inches. The second reach makes a dip to a distance of 24·925 miles, to a point about 3 miles beyond Masborough; the fall from the Derbyshire summit being 269 feet 1·92 inches. In this reach there are also thirteen planes, ten of which are descending, and have inclinations varying from 1 in 330 to 1 in 3911, and three ascending planes with inclinations of 1 in 660, 1 in 926, and 1 in 550 respectively. The third reach ascends to the Yorkshire summit, which is 157 feet 0·12 inch below that of Derbyshire, and 36 feet 4·68 inches above the Derby terminus. In this length there are eight planes, five of which are ascending, with inclinations of from 1 in 318 to 1 in 2173, two descending, with inclinations of 1 in 2764 and 1 in 487 respectively, and one level plane, which is 1·687 miles long. The fourth reach makes a dip to Methley, a distance of 23·825 miles, the whole fall from the Yorkshire summit being 124 feet 4·08 inches. In this reach there are seven planes, five of which are descending, with inclinations varying from 1 in 264 to 1 in 4224, one ascending, with an inclination of 1 in 640, and one level, for a length of ·125 mile. The fifth reach ascends for a distance of 4·412 miles, to a height above the second dip of 26 feet 5·88 inches. There are also seven planes on this length; four of which ascend at the rates respectively of 1 in 349, 1 in 1023, 1 in 446, and 1 in 440; two descending planes, with inclinations of 1 in 528 and 1 in 440 respectively; and one level plane, ·112 mile in length. Beyond this point there is one descending plane, with a fall of 1 in 264, for a length of 1·287 miles; and the Leeds terminal

plane is level for .162 miles, and 75 feet 8.64 inches below the Derby terminus.

Thus the whole distance between Derby and Leeds is 72.50 miles; the number of ascending planes being twenty-three, of descending planes twenty-two, and of level planes five. The aggregate length of level planes is 2.886 miles. The ruling gradient is 20 feet; the prevailing gradients range from 8 to 16 feet.

EARTHWORKS.—The excavations and embankments throughout this line are exceedingly heavy; indeed there is not in its whole length more than a mile of the railway which is not either raised above the general surface of the lands intersected, by embankments or viaducts, lowered by excavations, or carried through the natural barriers of the country by lofty tunnels. The aggregate quantity of the earthworks is nine and a half millions of cubic yards, or at the rate of 131,034 yards per mile.

Among the principal works in this department may be mentioned the Oakenshaw and Normanton cuttings. The Oakenshaw cutting is in rock, shale, and bind, the greatest depth of which is 50 feet, and its contents amounted to 600,000 cubic yards, the greater proportion of which was led to form the Oakenshaw embankment, the average lead being about one mile, and the cost being at the rate of 1*s.* 7½*d.* per cubic yard, and of that carried to spoil 1*s.* 4*d.* per cubic yard.

The Normanton cutting is 55 feet at its greatest depth, and contained 500,000 yards, chiefly of rock and blue bind, the produce of which was for the most part led to form the Altofts embankment, and 70,000 yards thrown out to spoil, the average lead being 1½ miles, and the cost per yard 1*s.* 3*d.*, and of that carried to spoil, 10*d.*

The slopes of cuttings are generally formed at 1 to 1, and of embankments at 1½ to 1. The whole width of cuttings is 33 feet, the top-width of embankments 36 feet, and on the top-surface of ballasting 26 feet.

The works were let throughout in upwards of thirty contracts, varying in length from half a mile to 4½ miles. The progress of the works in 1839 was so rapid, that not fewer than 450,000 cubic yards of excavation were effected per month, and the number of men employed amounted to about 8,600; besides which there were eighteen fixed engines, working chiefly at the tunnels.

TUNNELS.—The tunnels are seven in number, amounting altogether in length to 2·159 miles, or 11,400 feet; the first of which is situate at Milford, about six miles from Derby; the second, third, and fourth, are each but of short length, and are situate respectively in Duffield and South Wingfield parishes, and near Lodge Hill; the fifth is at Clay Cross; the sixth is carried through Cat Hill, in Darfield parish; and the seventh, called the Chevet tunnel, is near Sandal, and in the parish of Roystone. The principal tunnels are those of Milford, Clay Cross, and Roystone. The Milford tunnel is 836 yards long, that of Clay Cross 1760 yards, and the Roystone tunnel 700 yards in length.

The clear width of the tunnels at the level of springing-line of invert is 22 feet, and at the springing-line of arch 26 feet; the clear height above the level of rails being 24 feet. All the tunnels are lined either with masonry or stone; the vertical shafts are chiefly of 9 feet diameter. The Roystone tunnel through red sandstone and bind, and executed by five vertical shafts, is stated to have cost about 50*l.* per yard lineal; the whole is lined throughout with brickwork and masonry, of about 18 inches in thickness; but that at Clay Cross will have cost at the rate of more than double that sum per yard.

VIADUCTS AND BRIDGES, &c.—The whole number of bridges, including viaducts, carrying the railway over roads, rivers, and canals, is 133; and of bridges over the railway 71. The number of level road-crossings is nine, and of field or occupation-crossings on a level with the rails twenty-nine, respectively.

The bridges over the railway are of 30 feet span and 16 feet clear height from rails to soffit, and the clear width between the parapets of bridges under the railway is 28 feet 6 inches. The turnpike-road bridges under the railway are 16 feet in height, and of the whole width of the road.

Among the principal works in this department are the Oakenshaw viaduct over the Barnsley canal, the Calder viaduct near Altofts, and the Chevet viaduct near Sandal. The first of these consists of five segmental arches, each of 60 feet span, and having a versed sine of 15 feet; the arches are built of brickwork in cement, and consist of 9-inch rings, and the quoins

and dressings are of masonry. The height of this structure above the general surface of the land is 60 feet, and above the surface of water in the Barnsley canal 55 feet.

The Calder viaduct consists of one 90-foot segmental arch, having a versed sine of 30 feet, and five arches each of 60 feet span, with a versed sine of 24 feet. The piers are built with a curved batter, and are 10 feet at level of the water, and 9 feet at springing-line of arches; the whole is built of masonry and brickwork combined: the height from surface of ordinary level of water to rails is 34 feet.

The Chevet viaduct in Sandal parish consists of thirteen arches, each of 20 feet 6 inches span, the piers being 4 feet each in thickness.

Besides the numerous bridges and viaducts, there are several heavy works in the shape of stone retaining walls, the chief of which are at Bull Bridge and Woodlesford.

The brickwork and masonry in the north part of the district traversed by this line cost about 14*s.* per cubic yard; the bricks were supplied at 26*s.* a thousand.

GAUGE OF WAY, RAILS, &c.—The gauge is 4 feet 8½ inches where the rails are laid on sleepers, but where on blocks 4 feet 9 inches; the intermediate space is 6 feet 5 inches, and each side-space 8 feet 6 inches wide respectively.

The rails, which are partly from the great works of Sir John Guest and Co. at Dowlais, are of two kinds. The first are of the single parallel form (see Plate 3, fig. 51), similar to those of the Manchester and Leeds, Blackwall, and Chester and Crewe Railways, and weighing 56 lbs. to the yard lineal, being secured to the chairs with the ball-and-key fastening (see Plate 16); and the second description are of the double parallel form (see Plate 3, fig. 52), and weighing 65 lbs. to the yard, which are secured to the chairs by uncompressed fir keys, as on the Northern and Eastern Railway: each key is 9 inches long, and has a scantling of 3 inches by 2½ inches.

Both stone blocks and wooden sleepers are used as foundations for the chairs. The blocks are each 2 feet 2 inches square and 1 foot thick; those for the joints being placed in a parallel, and those for the intermediate points of support in a diagonal position; a method at first introduced on the

London and Birmingham Railway. The chairs are laid with a lateral inclination of about $\frac{1}{4}$ an inch, but are set on the blocks without felt; the reason for omitting which we are at a loss to imagine. The points of support for a 15-foot rail are six in number; those at the joints being at intervals of 2 feet 9 inches, and the intermediate bearings being each of 2 feet 3 inches. This plan is adopted on the Northern and Eastern Railway. The blocks cost from 4*s.* 6*d.* to 7*s.* each; some of them are of red sandstone, which is not favourable for such a purpose. The sleepers are of larch and Scotch fir kyanized, and are 9 feet in length, with a cross section of 10 inches by 5 inches: the kyanizing was performed at Goole, at a cost of 1*s.* for each sleeper. The chairs are fastened to the blocks and sleepers by $\frac{3}{4}$ -inch patent spikes, 6 $\frac{1}{2}$ inches in length. Spun yarn is bound round the top of the spikes before being driven into the blocks or sleepers. These spikes, which are of excellent workmanship, are supplied from Pope's establishment at Wolverhampton, at a cost of 16*s.* a cwt.

The ballasting consists either of broken stone, cinders, or burnt stone, according to the situation of the work, and is 2 feet in thickness where blocks are used, but only 18 inches where the rails are laid on sleepers.

The drainage is complete throughout. Down the centre of the cuttings rubble-drains are introduced, with cross drains into the open lateral drains. In the ballasting, transverse gullets are formed to carry off the surface-water.

The fencing consists chiefly of stout posts with four rails, and plantings of quick. The posts are altogether 6 feet 3 inches high, being fixed 2 feet into the ground, and 9 feet from middle to middle. An upright intermediate stay tends much to strengthen the whole.

Some of the fencing consists of three rails, with space and pale for the lower half. The cost of post-and-three-rail fencing and quick in the northern district of this railway is 2*s.* 4*d.* per yard lineal. The field-gates, with stout hanging and shutting-posts, cost each about 4*l.* Stone walling (see Plate 16) is substituted for wooden fencing in some parts of the line, the height of which is 4 $\frac{1}{2}$ feet above the ground, the top thickness being 1 foot 2 inches, and at the level of the ground 1 foot 6 inches. The cost of this description of fence built in mortar, with copings complete, is 1*s.* 6*d.* per yard lineal; but if built without mortar, except as to the coping, the price is 3*s.* 6*d.* to 3*s.* 9*d.* per yard.

The mile-standards are of wood, placed at intervals each of a quarter of a mile.

STATIONS AND DEPÔTS.—We have already stated that the stations on this line are on a grand scale; and we may add that, taken as a whole, they distinguish this line from all others in the kingdom.

Besides the trijunct station at Derby, and the Leeds terminal station at Hunslet, there are thirteen intermediate stations, which, taken in order with their respective lengths from Derby, are as follows:—Belper, $7\frac{1}{2}$ miles; Amber Gate, $10\frac{1}{4}$; Wingfield, 14; Chesterfield, 24; Eckington, $30\frac{1}{4}$; Beighton, 34; Masborough, 40; Swinton, 45; Darfield, $49\frac{1}{4}$; Barnsley, 53; Oakenshaw (about two miles from Wakefield), 60; Normanton, 63; and Woodlesford, 68 miles, respectively.

DERBY TRIJUNCT STATION.—The trijunct station at Derby belongs to the North Midland, Midland Counties, and Birmingham and Derby Railway Companies. The three lines unite at this station, the Midland Counties and North Midland approaching it by the same bridge over the Derby Canal, and the Birmingham and Derby Railway entering it from the south; the three being united under the grand passenger-shed, which is by far the most striking feature in the whole of this establishment. It is situate on the west side of the depôt towards Derby, and at a distance from the western boundary-wall of about 120 feet. The offices, which are on the same side, are contained in a building of good proportions, but not so pleasing to the eye as the buildings of the intermediate stations.

The principal part of this erection is 170 feet in length and 21 feet in depth, and consists of a central portion and two wings; besides which there is an addition at each end in one story of 28 feet in length and 18 feet in depth, making the whole extent of the offices 226 feet. The main building is in two stories, besides the basement. The central portion contains the entrance-hall and staircases, which ascend to the board-room and other offices on the upper floor. In the wings are contained the different booking-offices and waiting and refreshment-rooms, for first and second-class passengers, which are quite apart from each other. There are also water-closets and other conveniences, suitably placed.

The east front of this building is next to the passenger-shed, which

presents really an imposing sight, viewed either by day or by night. The light and lofty iron columns, each in imitation of the Roman fasces; the admirably contrived and elegant roofs; the spacious platforms; the great length of the whole erection, extending to upwards of a thousand feet,—all unite in rendering it the most complete structure of the kind in the United Kingdom, or, perhaps, in the world. But to enter a little more into detail. There are altogether nine lines of way under this shed, five under the middle span of roof, and two under each side-span, the whole width being 140 feet, and that of each platform 30 feet. Turn-tables are arranged on the several lines at each end and without the shed, and also at convenient intervals within. On the east side of the main shed the roof is supported by a brick wall, in which are twenty-three unclosed window-openings, which afford light to the shed, and prevent the unsightly appearance of a long and lofty blank wall. On the west side the roof is supported on the wall of the offices for its whole length, and the remaining length at each end by walls properly erected for its support. Intermediately the roof is supported by two lines of iron columns, altogether thirty-six in number; and beyond the main shed, the western platform is produced for a considerable length, and covered by one span of the roof, which is supported in front by twelve additional columns.

The North Midland locomotive department occupies the eastern angle of the entire area, and is about 390 feet in length by 340 feet in depth. The building for the locomotives occupies the western portion of the space set apart for the North Midland locomotives-department, and is of polygonal form, having sixteen sides, with as many lines of way radiating from a central turn-table. There are two entry-buildings or lobbies, over which are tanks of water for the supply of the locomotives; from the south-western lobby a line diverges to the Birmingham and Derby Railway; and from the north-western lobby a line is produced to join the main lines towards the bridge over the Derby Canal. Abutting on each of the lobbies above mentioned are the turneries, smithy, and other workshops, which enclose the space allotted to this department on the north-western and south-western sides.

The locomotive-engine dépôt of the Midland Counties Railway is situated on the space between the north-western side of the North Midland locomotives' buildings already described and the bridge over the Derby Canal, the whole length being 800 feet, and the area being nearly of regular triangular

form, the apex of which is near the canal-bridge. The buildings, including the workshops, locomotives' building, and tank and coke-building, are each of rectangular shape. The North Midland goods-department also forms part of this extensive trijunct station, which occupies altogether an area of about twenty acres.

The Leeds station is also on a large scale, but very inferior in point of dimensions to that of Derby. The passenger-shed, which is covered by a light iron roof in four spans, is furnished with five lines of way, three of which are under the central span, and one next to each of the passenger-platforms, each of which is 18 feet in width, the whole length of the shed being about 300 yards. Turn-tables are fixed at each end and at convenient intervals. At the north end, and without the shed, are docks for loading and unloading goods. The offices are on the up-side, and contain waiting-rooms for passengers, and separate rooms for ladies, booking-offices for the North Midland and also for the Manchester and Leeds Railways, and other suitable conveniences. In the front of the building is an arcade extending nearly its whole length; the approach to and departure from which is by two gateways opening into Hunslet Lane, which correspond with similar gateways on the opposite side for the departure of persons who have arrived by the trains. In the same line, and in the middle of the frontage next to Hunslet Lane, are two stone lodges of neat design, between which is a gateway for common-road wagons, which are drawn up to the docks at the end of the shed, where they are either loaded or unloaded as required.

The buildings are generally of red brick, with stone dressings. The goods-depôt, which is situate close to the station, is also on an extensive scale. The area occupied by the station and dépôt is equal to about fourteen acres; the cost of the former being about 14,000*l.*, and of the latter 7,000*l.*

The intermediate stations, as we have already observed, are on a grand scale, and consist of the usual booking-offices and waiting-rooms, an arrival and departure-platform of great length, with a water-column to each, and an engine-house; under the roof of which are also situate the water-closets and urinals, which is a much better arrangement than that in common use on other main lines, as the whole can be cleansed from the same tank which supplies the engines with water. The doorways, however, entering to these conveniences are in so exposed a situation as naturally to shock the female

portion of travellers, who, while the trains are stopping, cannot fail to observe the constant bustle about these buildings, and more especially when the bell rings for the departure of the train. A lobby without would in some measure remedy the great defect we allude to.

CARRIAGE DEPARTMENT.—The carriages consist of first, second, and third class. The first-class carriages are nearly on the same plan as those of the London and Birmingham and Grand Junction Railways, having three compartments, each of which will hold six persons; and the fittings-up being nearly of the same description.

The second-class carriages are also in three compartments, each holding eight passengers; but the compartments are separated entirely by close boarding, which is a decided improvement, and should be carried into effect with regard to all second-class carriages, which are open at the sides.

All the carriages are mounted on four wheels; the bodies are painted Spanish brown, and picked out with black.

The goods-trucks are similar to those used on the Northern and Eastern Railway. The weight of a truck (No. 179) is 2 tons 10 cwt. 2 qrs.; its length is 12 feet 6 inches, width 7 feet 5 inches, and height of four-paneled sides 21 inches; the soles are 9 inches by 3½ inches, and the solid buffers project 15 inches at each end.

FARES, TRAFFIC, &c.—The number of trains daily in each direction at the present time (Nov. 1840) is seven, except on Sundays, when there are five up and as many down. The fare for a first-class passenger between Derby and Leeds is 18s., and for a second-class passenger 12s., being at the rates of 2·979d. and 1·916d. per mile respectively. The double tickets which are given in London, or at Leeds, to persons travelling in either case beyond Derby, are divided at that place; one being delivered up to the guard upon his applying for the same at Derby, and the other before the arrival of the train at the London or Leeds terminus, as the case may be. Thus the accounts of each company are properly checked.

The receipts for passengers, parcels, and merchandise, from the 19th July to 31st October inclusive, amounted to 47,980l. 5s. 3½d., which is at the average rate of 456l. 19s. 1·17d. per diem.

The distance run by the Company's passenger-engines, with trains daily, according to the present number, in each direction as above, is equal to 1015, and on Sundays to 725 miles ; or altogether at the rate of 355,395 miles per annum.

LOCOMOTIVE DEPARTMENT. — The locomotive engines are all mounted on six wheels, and are chiefly supplied from the works of Messrs. Robert Stephenson and Co., Messrs. R. and W. Hawthorn, Messrs. Tayleur and Co., and Messrs. Mather, Dixon, and Co. The proportions of some of the engines of the above makers will be found in Table XXI. of British Locomotives, in the Appendix. The whole number of engines is about fifty. Those for the merchandise-traffic have four of their wheels coupled. The price of these engines varies from 1150*l.* to 1600*l.*, including tenders in each case.

The coke used on this line is made from the Derbyshire coals, and is supplied to the company at about 14*s.* a ton ; but it is rather surprising that the coke made from the Newton coals near Wakefield, which is of excellent quality, and very free from sulphur, is not also used. It is evident that it would be advantageous to the North Midland Company to use this coke for the Leeds division, if the prime cost on the railway at Oakenshaw is equal to or under that of the Derbyshire coke, delivered on the line at or near Chesterfield.

The following is a statement of the cost of the undertaking, up to 30th June, 1840 :—

Preliminary expenses and obtaining the Act of incorporation	£ 41,349 12 3	
Parliamentary and law-charges	4,105 15 1	
		£ 45,455 7 4
Law-charges for general purposes		14,887 15 7
Lands and compensations		350,388 19 4
Engineering	45,522 4 7	
Surveying and land-valuing	7,038 14 0	
		52,560 18 7
Earthworks, bridges, tunnels, &c.	1,619,861 2 10	
Permanent way	315,622 0 2	
Stations (on account)	66,418 15 7	
		2,001,901 18 7

Wagons, trucks, &c.	.	.	.	.	.	£ 8,470	0	4	
Coaching stock	.	.	.	.	.	23,838	9	10	
Locomotive stock	.	.	.	.	.	71,082	2	4	
									103,390 12 6
Direction	.	.	.	.	.	7,850	0	0	
Office-charges, including salaries, rents, stationery, printing, &c.	.	.	.	.	.	8,460	1	0	
Advertising, printing, &c.	.	.	.	.	.	2,472	16	3	
Police	.	.	.	.	.	2,119	5	7	
Sundries	.	.	.	.	.	5,452	2	10	
									26,354 5 8
Interest on debenture-bonds	.	.	.	.	.	36,502	16	7	
Stamps for ditto	.	.	.	.	.	4,500	0	0	
									41,002 16 7
									£ 2,635,942 14 2

Thus the cost per mile, up to the 30th of June, 1840, was at the rate of 36,357*l.* 16*s.* 7·20*d.*; whereas the original estimate was 1,250,000*l.*, and the parliamentary estimate, including 140,027*l.* to meet any extraordinary expenses, was 1,500,000*l.*, or at the rate of only 20,689*l.* 13*s.* 1·24*d.*

The whole of the works, which are of the most substantial description, have been executed under the general direction of Mr. Frederick Swanwick, the acting engineer, who has used every exertion to get the whole line completed in the least possible time. The Company have also been fortunate in having the services of Mr. Dyson, as resident engineer, for a considerable portion of the north part of the line. Mr. Robert Stephenson is the general manager of this railway, and Mr. Pattison the secretary. During the execution of the works, Messrs. G. and R. Stephenson were the principal engineers.

NORTH UNION RAILWAY.

THE outcry against second-class gradients, which but a short time since was so frequently heard to re-echo through the committee-rooms and lobbies of both houses of parliament, is gradually assuming a milder tone ; and now the angle of repose, at which it was lately considered necessary to fix the ruling gradient of a locomotive's line, is found not to be absolutely requisite for the effectual working of grand trunk railways.

The North Union line has now been efficiently worked for two years ; and it has not fewer than ten planes, inclining at the rate of *one in a hundred*, amounting together to nearly five miles.

The country through which this railway is constructed is exceedingly rugged, and the description of strata intersected very unfavourable for the earthworks, causing continual expense in repairing the slopes both of the cuttings and embankments.

The southern portion of this railway, lying between Parkside and Wigan, a distance of 6·931 miles, was originally called the Wigan Branch Railway, the Act for which received the royal assent on the 29th May, 1830 ; and on the 22d April, 1831, an Act was obtained for making a railway from Preston to Wigan, in order to connect these places with Liverpool and Manchester. The two lines were subsequently united ; and now the whole is called the North Union Railway, which forms one of the links in the present railway chain between London and Lancaster.

By the Act for the Wigan branch the Company were empowered to raise a capital in joint-stock of 70,000*l.* in 100*l.* shares, and by loan 17,500*l.* By the Preston and Wigan Act the capital authorised to be raised was 250,000*l.* also in 100*l.* shares ; and power was given to the Company to borrow an additional sum of 83,000*l.* ; but by the Act subsequently obtained in 1834 for consolidating the two railways, power was given to the Company either to raise by new shares or by loan 160,000*l.*, no money having been raised by loan, as authorised by the previous Acts. In 1840 the fourth Act was obtained, which is dated March the 23d. By this Act the Company obtained power to raise a further sum of 250,000*l.*

Thus the whole amount authorised to be raised by the several Acts as above is 730,500*l.*; but the Company have not exercised the powers given to them with regard to raising all the loans. Up to 1839 the aggregate sum of 460,000*l.* had been raised by shares, and 20,000*l.* by loans, making together 480,000*l.* Since that time, however, a further sum of 250,000*l.* has been authorised to be raised. The whole number of shares is 6329.

GENERAL COURSE OF THE LINE.—Leaving the northern terminus at Dock Street, Preston, the line follows nearly a southern course; passing to the west of Woodford End and Leyland, about two miles to the east of Eccleston; thence continuing to Cophall, Standish, and Wigan; from whence it is produced to the east, and within two miles of Park Lane, and falls into the Liverpool and Manchester Railway at Parkside; the whole distance being 22·236 miles.

INCLINATIONS.—Commencing at Dock Street, Preston, which is 86½ feet above the level of the Old Dock sill at Liverpool, the inclinations (as obligingly furnished to us by Mr. Coulthard, one of the resident engineers of the line) are as follows:—

Lengths of Planes.		Ratio of Inclination.		Locations.
Yards.				
203½	. . . . .	descending at the rate of 1 in 100		
1368	. . . . .	descending „ 1 in 330		
1518	. . . . .	ascending „ 1 in 330		
1100	. . . . .	ascending „ 1 in 100		Bamber Hillocks.
3520	. . . . .	ascending „ 1 in 330		
760	. . . . .	ascending „ 1 in 100		
1660	. . . . .	ascending „ 1 in 440		
2750	. . . . .	descending „ 1 in 660		River Yarrow.
1584	. . . . .	ascending „ 1 in 100		
350	. . . . .	ascending „ 1 in 330		
946	. . . . .	ascending „ 1 in 100		
1210	. . . . .	ascending „ 1 in 330		
616	. . . . .	ascending „ 1 in 100		
958	. . . . .	ascending „ 1 in 528		
770	. . . . .	descending „ 1 in 100		
3740	. . . . .	descending „ 1 in 330		

Lengths of Planes.		Ratio of Inclination.		Locations.
Yards.				
1298	. . . . .	descending	„ 1 in 100	
462	. . . . .	descending	„ 1 in 330	
1100	. . . . .	descending	„ 1 in 100	
814	. . . . .	descending	„ 1 in 330	
209	. . . . .	level	. . . . .	Wigan station.
253	. . . . .	descending	„ 1 in 100	
990	. . . . .	descending	„ 1 in 330	
1326	. . . . .	descending	„ 1 in 754	Bryn Hill.
660	. . . . .	level.		
1320	. . . . .	ascending	„ 1 in 2200	
1754	. . . . .	ascending	„ 1 in 586	
1232	. . . . .	ascending	„ 1 in 440	
4664	. . . . .	descending	„ 1 in 406	Parkside.
<hr/>				
39,135 yards, or 22·236 miles.				
<hr/>				

The length of the New Springs branch, which leaves the main line at rather more than $16\frac{1}{2}$ miles from Preston, is 2 miles 54 chains in length, having inclines of 1 in 132, 1 in 30, and 1 in 880, respectively. The steepest inclination of this line is 1 in 100. As regards gradients, it comes within the second class of railways.

The ascending planes, rising 1 in 100 from Preston to Wigan, amount to 5006 yards; and in the opposite direction to $3624\frac{1}{2}$ yards; or together 4·90 miles, being equal to nearly one-fifth of the whole length.

This is an important fact, as shewing the inutility of spending large sums of money in reducing hills and filling up valleys to so great an extent as has been done on many of the great lines of the kingdom for the purpose of making the gradients as easy as possible. But the results shewn below, under “Locomotive-Department,” speak volumes in favour of an economical original construction.

EARTHWORKS.—The earthworks are very heavy on account of the rugged country passed through, and the slippery nature of the strata intersected. Among the principal works in this department may be mentioned the Ribble Valley embankment, the Penwortham Hill cutting, the Yarrow Valley embankment, and the Wigan embankment.

The average length of lead throughout was about $1\frac{1}{2}$ miles.

The largest embankment is that at Wigan, containing about 600,000 cubic yards; the average cost of which per yard was about 10*d.* The top width of embankments is 24 feet.

In very shallow cuttings and embankments the slopes are 1 to 1; but where up to 15 feet in depth $1\frac{1}{2}$ to 1; and above that depth 2 to 1. Where the slopes are of a slippery nature, which is to a considerable extent in the Preston division, short piles are driven in, and watling is resorted to.

The embankments have earthen walls at the sides, as in the Liverpool and Manchester Railway.

The whole amount of cuttings is 2,903,028 cubic yards, which gives an average per mile of 116,120 cubic yards; the average cost throughout being under 10 $\frac{1}{2}$ *d.* per yard; and the whole cost of the works in this department being 126,000*l.*, or at the rate of 5000*l.* per mile.

TUNNELS, BRIDGES, &c. — There is one short and slightly curved tunnel, 77 yards long, under Fishergate, Preston, near the junction with the Lancaster and Preston Railway. It is constructed of brick and stone. The arch is $2\frac{1}{2}$ bricks in thickness, and of semi-elliptical form, and 30 feet in span; the clear width at level of rails being $28\frac{1}{2}$ feet.

The bridge carrying the railway over the river Ribble is chiefly constructed of millstone-grit from Longridge, and other similar quarries. It consists of five semi-elliptical arches, each of 120 feet span, and rising 33 feet. The piers are 20 feet each in thickness. The height from the surface of the water to the level of rails is about 44 feet. The whole presents a bold appearance when viewed from the banks of the Ribble.

The bridge carrying the railway over Walgate, Wigan, is 46 feet in length and 36 feet in width, and is built on the level-beam principle; the iron beams or girders being supported intermediately by two rows of cast-iron fluted Doric columns, six on each side, which separate the footways from the carriage-way.

On our view of this line we counted 28 bridges over the railway, 21 bridges under, 13 level road-crossings, and 38 level occupation or field-crossings.

The bridges over the railway are 30 feet in span, and $16\frac{1}{2}$ feet in clear height. The occupation-bridges under the railway are 12 feet in height.

The bridges are generally built of stone, with brick arches. The contents of the whole of the masonry are equal to 100,265 cubic yards, the total cost being 113,096*l.* 0*s.* 5*d.*, or about 22*s.* 7*d.* per yard. The iron-work of bridges amounted to 325 tons, the cost being below 9*l.* 15*s.* per ton; and of timber the total quantity is 25,022 cubic feet; the whole amount in this department being 120,248*l.* 15*s.* 1*d.*

GAUGE OF WAY, &c. — The gauge is 4 feet 8½ inches; the intermediate space 6 feet 5 inches; and the side-spaces each 4 feet 1 inch to the edge of each open drain, making the whole width 24 feet. The rails are of the double parallel form, weighing 60 lbs. per yard (see Plate III. fig. 53), and are secured in chairs by English oak keys uncompressed, 7 inches long, and measuring 3 inches by 2 inches, and for the intermediate chairs 9 inches long, with the same scantling for the joint-chairs; the cost of the former being 3*d.*, and of the latter 3½*d.* each. The joint-chairs weigh 21 lbs., and the intermediate chairs 20 lbs. each. The sleepers, to which the chairs are spiked down on embankments, are 9 feet in length, and have a scantling of 10 inches by 5 inches. The cost of each sleeper, if of larch, was 5*s.*; and if of Memel timber, 5*s.* 6*d.*

The blocks used in the cuttings, and where the railway is near the surface of the lands, are of Longridge grit, and measure 2 feet 3 inches square and 1 foot thick. A medium of felt is introduced between the chair and the block: each piece of felt costs ¼*d.*, and measures 10 inches × 5 inches.

The bearings of rails are 3 feet 9 inches and 4 feet respectively.

On the New Springs branch the rails are of the T-form, weighing 45 lbs. to the yard, and in 15-foot lengths, with 3-foot bearings. The sleepers are the same as for the main line; but the blocks are only 4 feet square and 1 foot thick.

A single way is only laid on this branch, although the land and bridges are provided for a double way. Mr. Coulthard estimated the cost of laying a double way, similar to that of the North Union Railway, with blocks at 30*s.* a yard lineal; and with sleepers at 27*s.* a yard lineal, respectively.

On the embankments whole timbers are introduced transversely to connect the two sets of rails together.

The ballasting consists of sand, with an upper layer of broken stone 4 inches in thickness.

The open drains on each side of the cuttings are built of stone, and are 18 inches wide at top and 2 feet 9 inches deep, the outer wall being 15 inches and the inner wall 12 inches in thickness. The bottom is formed of 3-inch stone flags. The width from the outer rail to the outside of the drain-wall next the slopes is 6 feet 10 inches.

The fencing consists of posts and three rails on the outside of the ditch, which costs complete 2s. per yard lineal. The distance-posts are placed on one side of the railway, at intervals each of a quarter of a mile.

STATIONS AND DEPÔTS. — The principal stations are at Parkside, Wigan, and Preston. That at Parkside belongs jointly to the Grand Junction and North Union Railway Companies. It is a neat building placed on the south side of the Liverpool and Manchester Railway, at a distance of 9 feet 10 inches from the outer rail, the platform in front being paved, and 7 feet in width; and the side-space of the railway being 2 feet 10 inches. The whole length of this building, which is in two stories, is 76 feet, and the depth 18 feet. On the ground-floor are a booking-office, and general waiting-room in the middle; on one side a ladies' waiting-room, and on the other a private office. On the upper floor are apartments occupied by the book-keeper.

The station at Wigan is approached by a sloping road from Walgate, 24 feet in width. On each side of the railway is a paved platform, 8 feet 6 inches wide, covered by a colonnade in front of each building, the whole length of which is about 70 feet. On the side next Wigan is a booking-office, a first-class waiting-room, a second-class waiting-room, and a ladies' private room; and of the building on the other side, the chief part is occupied by a carriage-house 24 feet wide, and having two lines of way, which run into the main line. The remainder of the ground-floor is occupied by a general waiting-room and booking-office. On the basement are cellars for wood, coals, &c. The whole width between these buildings is 40 feet 5 inches; the intermediate space 6 feet 6 inches; and each side-space 3 feet 9 inches.

The station at Preston is approached from Fishergate by a carriage-road and footway of ample width, with sufficient space for common-road conveyances in waiting.

The building contains a booking-office for the Liverpool and Manchester Railway, and another for the London line, together with waiting-rooms and

other conveniences; and above are the private offices of the Company. In front is a shed supported on cast-iron columns, which carries a double way expressly for the Preston traffic; while the main double way passes outside, and continues under Fishergate to its junction with the Lancaster and Preston Railway.

There is a carriage-repairing and building-house for the four lines of way from end to end, and a loft of equal area above it. One transverse line, with five turn-tables, renders the communication complete between the railway and the carriage-house.

At this station there is a large board hung up outside the booking-office, containing the names of the different mails and coaches leaving Preston, with their times of starting; a plan which it would be well to follow on many other lines similarly circumstanced.

Between the carriage-house and station-buildings there is a double carriage-landing, furnished with turn-tables.

The goods-depôt, which is leased, together with the carriage of goods on this line, to Mr. Hargreaves, of Bolton, is opposite the station-building. It occupies a space equal to about 2430 superficial yards.

The average height of the Preston station, which is partly raised on arches, is about 20 feet; and the whole area occupied is about 4 acres.

The intermediate stations are at Colborn, Wigan, Standish, Cophall, Euxton, Golden Hill, and Farrington. Expensive buildings have been very judiciously avoided at the minor intermediate stopping-places of this railway.

CARRIAGES. — In November 1839 the following was an account of the carriages, &c. belonging to this Company:—

No.	Description.	No. of Compartments.	To hold No. of Persons.	Wheels.	Total weight. tons. cwt. qrs.	Cost.
20 . .	1st class . .	3 . .	18 . .	. { Losh's 3 feet }	. . 3 10 0 . .	£ 420
15 . .	2d class . .	3 . .	24 . .	. . ditto . .	. . 3 0 0 . .	£ 200
12 . .	{ Carriage- trucks }	size 14 ft. 6 in. X 7 ft. 6 in.	. . . . .	. { ditto 2 ft. 6 in. }	. . 2 3 0 . .	£ 130
6 . .	{ Horse- boxes }	. . . . .	. { 3 horses each }	. { ditto 3 feet }	. . 2 5 0 . .	£ 130

The first-class carriages are constructed with ash framing and mahogany linings, and lined inside with cloth, and furnished with cushions, &c., as those of the Grand Junction Railway. They are painted green, and picked out with black. The buffing apparatus on some of the carriages is on Mr. Booth's, and others on Mr. Worsdell's plan. There is about 2000 lbs. weight of iron in each carriage.

The second-class carriages are similar to those of the Grand Junction Railway, are open at the sides, and have lockers under the seats.

The carriages are furnished with outside lamps, made by Mr. Welch, of Birmingham, at 2*l.* each, except those which run through to London, which latter are supplied by Mr. Lowe, of Birmingham, and cost 26*s.* each. The carriages are not furnished with footboards, which would add greatly to the safety and convenience of both the passengers and guards.

At Preston there is a spacious carriage-shed erected on arches to the west side of the railway.

TRAINS, FARES, &c.—The number of trains daily leaving Preston, except on Sundays, and going to Liverpool, Manchester, and the south, is six; and of trains going north from London to Liverpool and Manchester, five. On Sundays there are three trains in each direction. Each train is conducted by one guard, who takes his seat in a second-class carriage to apply the brake when necessary. The average time of performing the distance from Parkside to Preston, or *vice versa*, 22·236 miles, is about one hour, including stoppages. The tickets are taken at starting from Preston. The fares for first-class passengers are at the rates of 2·43*d.*, and for second-class passengers 1·62*d.* per mile respectively.

The railway was opened to the public on the 31st October, 1838, and for six months ending the 30th of April, 1839, the number of passengers conveyed by the trains amounted to 68,547, or at the rate of 376 per diem; the receipts for the same period for passengers, parcels, &c. being 12,646*l.* 12*s.* 7*d.*, or at the average rate of 69*l.* 5*s.* 11*d.* per diem. From May to December 1839, both inclusive, the number of passengers conveyed by the trains amounted to 135,482, or on an average at the rate of nearly 553 per diem; the receipts on this account for the same period being 22,796*l.* 16*s.*, or at

the average rate of 93*l.* 0*s.* 11·52*d.* per diem. At the present time (November 1840) the passengers average 570 per diem.

LOCOMOTIVE-DEPARTMENT. — By reference to Table XXII. of British Locomotives, in the Appendix, the proportions of the engines used on this line will be readily seen. They are all on Bury's plan of construction, with four wheels, except the St. George, which has six wheels. We found the average weight of seven passenger-trains in 1839 to amount to 45,589 lbs.; the average velocity to be at the rate of 26·20 miles per hour; the highest velocity to be at the rate of 42·85 miles per hour; and the stoppages to average each 1·81 minutes. Thus, on a line, one-fourth of which is graduated with the maximum of second-class gradients, we find the average speed of the passenger-trains, weighing on an average upwards of twenty-three tons, to amount to more than 26 miles an hour.

The locomotive-depôt is near the passenger-station at Preston. This building is divided into three compartments — the engine-house, the fitting-shop, and the smithy. The engine-house will hold five four-wheeled engines and tenders, on five lines of way which run into the main lines.

In the fitting-shop are four lathes and one planing machine, which are worked by an eight-horse engine, fixed in the smithy compartment, in which are four hearths.

The boiler-room and hooping-shed are of the same width as the smithy; and the engine has a 12-inch cylinder and 18-inch stroke, the usual pressure of steam being 18 lbs. on the square inch. The boiler is multi-tubular, 6 inches in diameter, and having eighty-two tubes.

Besides these buildings, there is also an engine-shed for three engines and tenders.

DETAILED COST OF THE RAILWAY.—The following abstract of the quantities and cost of the works upon the line of the North Union Railway, twenty-five miles in length, with the general heads of expenditure in the various departments, is the first document of the kind we have met with; and we trust the example set by Mr. Vignoles will shortly be followed by the engineers of all other lines in the kingdom :—

<i>Earthwork</i> . .	2,903,028 cubic yards (average 10½ <i>d.</i> per yard)	£ 125,676	3	11		
<i>Masonry and Bridges</i> {	100,265 cubic yards masonry	£ 113,096	0	5		
	325 tons iron-work	3,875	0	0	120,248	15 1
	25,022 cubic feet timber	3,277	14	8		
<i>Fencing and Drains</i> {	87,712 lineal yards.— <i>N.B. This includes road-diversions, &c., gates, &c. &c.</i>				20,533	2 7
	6,885 tons of iron rails and chairs	£ 66,833	17	7		
<i>Upper Works</i> {	91,545 lineal yards of railway, laid on blocks and sleepers, including ballast, drains, walling, bolts, keys, felt, plugs, and small materials and labour	61,538	0	2	128,368	17 9
<i>Land and Damages</i> {	320 acres for railway				49,342	3 10
	Land for stations	£ 17,257	15	5		
<i>Stations</i> . . .	Station-buildings	13,589	8	1	£ 44,278	0 0
	Warehouses	9,266	0	0		
	Fixtures, turn-plates, and sundries	4,164	16	6		88,960 4 5
<i>Carrying Establishment</i> {	Repairing-shops, tools, and fixtures	11,884	0	0		
	Locomotive engines, tenders, &c.	18,863	6	7	43,682	4 5
	Carriages, horse-boxes, trucks, &c.	12,934	17	10		
<i>Interest</i>	Interest-account, rates, taxes, &c. &c.				4,746	15 8
<i>Management</i> .	Parliamentary and law-expenses	17,147	8	0		
	Engineering and surveying	6,193	5	9	42,055	12 11
	Office-expenses, travelling, advertising, &c.	3,134	19	2		46,802 8 7
	Salaries	15,580	0	0		
<i>Total Cost</i>					£ 578,931	16 2

Thus the average cost per mile is 23,157*l.* 5*s.* 6*d.*, a sum comparatively small when set in juxtaposition with the actual cost of several other main lines of railway.

The receipts and disbursements up to the 30th June, 1840, were as follows :—

<i>Receipts.</i>	
Coaching-department	£ 28,861 17 1
Coal-department	467 16 5
Merchandise-department	2,564 10 5
Rental-account	500 0 0
	£ 32,394 3 11
Profit and loss account, to 31st December, 1839	406 11 5
	£ 32,800 15 4

Receipts brought forward £ 32,800 15 4

Expenses.

Coach-disbursement account	£ 1,982 14 5		
Locomotive-power account	3,783 1 9		
Office-expenses account	207 13 11		
Salary-account	853 2 0		
Toll (to Liverpool and Manchester Co.) account	7,189 17 2		
Petty-disbursement account	12 13 10		
Interest-account	140 19 0		
Interest on loan-account	766 11 10		
Tax and rate account	502 0 4		
Chief rents account	43 13 4		
Charge for direction account	300 0 0		
Maintenance of way	600 0 0		
Compensation	3 3 0		
Fire-insurance	2 12 6		
Advertising	2 9 0		
Repairs for buildings	13 9 11		
		16,404 12 0	
		<u>£ 16,396 3 4</u>	

Dividend of 50s. per share on 6329 shares is 15,822*l.* 10*s.*

Thus the disbursements in carrying on the traffic of this railway for six months, ending 30th June, 1840, amounted to 16,404*l.* 12*s.*; being equal to 51·43*l.* per cent on the coaching, coal, and merchandise revenue.

The expenditure in the locomotive-department was at the rate of 7,546*l.* 3*s.* 6*d.* per annum; the cost of maintenance of way was at the rate of 1200*l.* per annum, which is equal to 48*l.* per mile. This is, indeed, a very small sum as compared with the expenditure in this department on other lines.

PAISLEY AND RENFREW RAILWAY.

It has generally been found in practice that short lines of railway are far less profitable to their proprietors than long lines. Nor will this appear strange, when it is considered that similar terminal stations and establishments are required, with an equal amount of traffic per mile in each case, without any additional recompense in the shape of higher fares.

The Paisley and Renfrew Railway is an illustration of the above remark; and we fear that the opening of the Ayrshire line will cause the hitherto very limited traffic to fall off considerably.

COURSE OF LINE, &c.—The course of this railway is in a direction nearly north-west from the Paisley station to that of Renfrew, which is situate on the south bank of the river Clyde. The whole distance is three miles; and the top-surface of the rails is nearly level.

EARTHWORKS, GAUGE OF WAY, &c.—The earthworks are but slight throughout. There is only one bridge, which is over the railway; the arch is of semi-elliptical form; and the whole is built of stone. There are four level road-crossings, and nine level occupation or field-crossings. The width of land is sufficient for a double way, although one set of rails has been found sufficient; at the Renfrew station the total width of land is 47 feet.

The gauge of way is 4 feet 6 inches, which is the original Scotch standard; the intermediate space, where the line is double at the stations, being 4 feet 8 inches.

Light rails are used throughout, which are fixed in chairs at intervals of 3 feet; the chairs are bedded on stone blocks in the usual way.

The fencing consists chiefly of stone walls; at Renfrew the station is enclosed with space-and-pale fencing 6 feet in height. The distances are marked from either end of the line on stone standards, fixed at intervals each of a quarter of a mile.

The station and dépôt at Paisley are sufficiently capacious for a large amount both of passengers and goods-traffic. This station is entered by car-

riage and foot-gates, which are contiguous to the booking-office. In the rear of the booking-office is a general waiting-room, or passenger-hall; and on the upper floor are rooms for the manager.

The passenger-shed is furnished with two lines of way laid from end to end, which are produced to the main line.

On the left of the way going to Renfrew is the locomotive engine-shed; and on the opposite side the goods-warehouse, with a single line running through it. This building is about 66 feet in length by 30 feet in width.

At Renfrew the passenger-shed is about 60 feet in length and 28 feet wide, having two sets of rails; on the west side of the shed a single way passes to a jetty on the south bank of the Clyde, where steam-boat passengers land and embark.

CARRIAGES.—There are altogether seven carriages belonging to this company, chiefly second class, in four compartments, and weighing about three tons each. They are generally 16 feet 6 inches long, 6 feet wide, and 5 feet 6 inches high; each compartment will hold eight persons. The wheels are 2 feet 9 inches in diameter, and have outside bearings. Foot-boards are fixed on each side, as on most of the Scotch railway-carriages. We observed one closed carriage, the body of which is 12 feet 7 inches long, 6 feet wide, and 5 feet 5 inches high, in three compartments, having cushions on the seats, but no inside linings. Instead of side-lights there are blinds, four to each compartment. The foot-boards are each about 2 feet 8 inches above the level of the rails. This carriage is fitted up with lockers under the seats.

Some of the second-class carriages have one closed compartment for first-class passengers. The open carriages cost each 150*l.*; and the first-class carriage 170*l.*

The trucks used on this way are eight in number, and are constructed of wood. These are of two sizes; the first being 14 feet 3 inches long at top, 11 feet 9 inches long at bottom, 6 feet 6 inches wide, and 2 feet high; the soles are 10 inches by 5 inches, and 3 feet apart; the outer longitudinal plates 6 inches by 5 inches; and the joists or cross pieces are of the same scantling. The bottom and sides are 1 inch thick; the sides have a batter of about 3 inches in their height. The wheels are of cast iron, 2 feet 9 inches in diameter, with outside bearings. From the level of rails to the under side

of soles the height is 2 feet 8½ inches ; the weight is about two tons ; and the cost without wheels 12*l*.

The second-sized trucks are 12 feet long, 6 feet 6 inches wide, and 2 feet high, with a batter as the last. The weight is about 1½ tons.

FARES, TRAINS, &c.—The trains during the summer months run in each direction every half-hour during the chief part of the day. The time occupied in performing the distance of three miles is usually about 12 minutes. The line was opened to the public on the 3d April, 1837.

The first-class fares are at the rate of 2*d*., and second-class fares 1·33*d*. per mile respectively. The number of passengers conveyed by the trains in 1838 amounted to 143,180, which is equal on an average to 457 per diem ; and in 1839 the total number fell off to 125,145, in consequence of the fares being raised to 2·66*d*. and 2*d*. per mile respectively ; but in April 1839 they were reduced to the original rates of charge.*

LOCOMOTIVE-DEPARTMENT.—The locomotive engines are three in number, viz. the Paisley, the Renfrew, and the St. Rollox ; the former two were built by Messrs. Murdock, Aikin, and Co., of Glasgow, and cost each 1100*l*. The St. Rollox was built by Messrs. R. Stephenson and Co., of Newcastle, and purchased of the Garnkirk and Glasgow Railway Company for 350*l*.

The Paisley and Renfrew have each six wheels ; the tender is supported on the soles of the engine, which are extended lengthwise for that purpose. The consumption of water for a double trip of six miles is about seventy gallons. The coal used for the engines is from Kipps, near Monkland, and is delivered on the line at 9*s*. a ton. The consumption of coal per day in the summer is stated to be about 2 tons.

The number of double trips daily during the summer months is ten.

* Feeling aggrieved at the unequal pressure of the government-duty of ½*d*. per mile for each passenger, this Company caused a petition to be presented to the House of Commons in the session of 1840, stating that their funds had been such, that for the first year only were they able to make a dividend on their subscribed capital, and that of only 2½ per cent ; that the mileage-duty absorbed more than 10 per cent of their income from passengers ; and that, with their comparatively low fares, they were as heavily taxed as if their charges had been of the highest rate.

Thus the whole distance run per day is equal to sixty miles, or at the rate of 18,780 miles per annum.

THE ESTABLISHMENT.—The persons employed on this line consist of a manager, who also attends to the ticket-department at Paisley; one ticket-collector at Renfrew; two porters at 15*s.*, and three at 12*s.* a week each; two engine-drivers, whose wages average each 22*s.* 6*d.*; and two firemen at 8*s.* a week respectively; besides three labourers.

The Act for the construction of this railway received the royal assent on the 21st July, 1835; and authorised the company to raise a capital in joint-stock of 23,000*l.*, and by loan an additional sum of 10,000*l.*

The whole of the railway and works have cost about 30,000*l.*, or at the rate of 10,000*l.* a mile. The paid-up capital is 19,016*l.*

RECEIPTS AND EXPENDITURE.—The receipts for passengers during the year 1838 amounted to 2,489*l.* 9*s.* 6*d.*, and for goods to 493*l.* 0*s.* 1½*d.*; together, 2,982*l.* 9*s.* 7½*d.*; or at the rate, on an average, of 9*l.* 10*s.* 6·88*d.* per diem.

In the year 1839, the receipts for passengers amounted to 2,330*l.* 10*s.* 10*d.*, and for goods to 674*l.* 7*s.* 2½*d.*; together, 3,004*l.* 18*s.* 0½*d.*

For the year ending the 15th May, 1839, the receipts amounted to 3,041*l.* 3*s.* 1*d.*, and the disbursements for the same period to 2,613*l.* 4*s.* 4*d.*, which is at the rate of 85·92*l.* per cent on the gross revenue.

This railway was designed by, and executed under the direction of, Mr. Grainger, of Edinburgh.

SHEFFIELD AND ROTHERHAM RAILWAY.

SHEFFIELD has been long and justly celebrated for the various descriptions of cutlery made at the numerous establishments in this improving town, the population of which, according to the last census, amounted to 91,692 souls. Before the introduction of railways, a journey from London to this place was attended with considerable fatigue, and occupied the best part of twenty-four hours; whereas, by the united efforts of four private companies, Sheffield is now within little more than an eight hours' easy drive of the metropolis. The Sheffield and Rotherham Railway is the shortest link of this chain, communicating by a short branch with the North Midland Railway at Masborough.

ACTS OF PARLIAMENT.—The Act for the incorporation of this Company received the royal assent on the 4th of July, 1836, and authorised a capital to be raised of 100,000*l.*, and by loan 30,000*l.* additional. On March the 23d, 1840, a second Act was obtained, empowering the Company to raise a further sum of 70,000*l.* by shares. The number of original 25*l.* shares is 4000, besides which there are half-shares. The joint-stock capital is 170,000*l.* The whole of the 30,000*l.* authorised by the first Act to be raised by loan has been taken up.

COURSE OF THE LINE.—Leaving the station at the bottom of the Wicker, Sheffield, the railway passes nearly in a direct line to Brightside, at which place is situate the first intermediate stopping-place; thence, following a slightly curving course close to Jerdan's Dam, on the river Dun, continues to the Holmes, just beyond which the branch to the North Midland Railway at Masborough curves off to the left. This branch continues by a single way for a mile alongside this line to the Greasbrough canal. From this point of divergence the main line passes under the North Midland Railway, across the River Dun Company's new cut, and also across the river Dun, to the station at Rotherham, situate in Westgate. From Brightside to Rotherham the whole way is slightly curvilinear.

The inclinations, commencing at Sheffield, are as follows :—

Lengths of Planes.		Ratio of inclination.		Locations.
Chains.				
24	. . . . .	descending at the rate of 1 in 729		To end of station.
44	. . . . .	descending „ 1 in 341·64		Hall Carr Wood.
30	. . . . .	descending „ 1 in 495		
40	. . . . .	level		Grimesthorpe Bridge.
30·8	. . . . .	descending „ 1 in 508		
21	. . . . .	descending „ 1 in 693		
73·6	. . . . .	descending „ 1 in 462		
45·2	. . . . .	descending „ 1 in 372		Jordan Lane.
35·2	. . . . .	descending „ 1 in 387		
2	. . . . .	level		The Holmes station.
10	. . . . .	descending „ 1 in 330		Top of Incline.
18	. . . . .	descending „ 1 in 67·88		Bottom of Incline.
52	. . . . .	ascending „ 1 in 858		Rotherham station.

The whole length of the main line is, therefore, 5 miles 25·80 chains ; and in point of gradients, this comes under the third class of railways, having a ruling gradient of nearly 78 feet, although, with this exception, the gradients are exceedingly favourable. In the original section there was no inclination greater than 1 in 470.

EARTHWORKS.—The total quantity of cuttings amounted to 404,768 cubic yards, and of side-cuttings 7900 yards, or at the rate of about 76,000 yards per mile. Of the whole amount 333,852 cubic yards were led to form the embankments, and the remainder to spoil.

BRIDGES.—We counted six bridges over the railway, seven road and other bridges under, and five occupation-arches also under the railway, four level road-crossings, two level field-crossings, and five level footpath-crossings.

The bridges are built of iron, timber, brick, and stone. The chief bridge is over Blackburn Brook, consisting of five openings, each of 20-feet span. The piers are built with a considerable batter, being 33 feet long at the base and 6 feet wide, and at top 31 feet long and 3 feet wide.

The bridges over the railway are 16 feet in height. The parapets of the bridges are unusually heavy, being 18 inches in thickness, surmounted by

stout parapets 21 inches high. A great expense is unnecessarily incurred, not only on this but on many other railways, in the item of parapets for bridges under the railway. Parapets for common road-bridges are of use in preventing vehicles, horses, and passengers, from falling over the sides; but in the case of a railway, the wheels have one certain track to follow, and except in the event of a train happening to go off the rails at the very point where a bridge occurs, are certainly not required.

GAUGE OF WAY, RAILS, &c.—The width of land enclosed, independent of that for slopes, is 20 yards. The gauge of way is the English standard, and the intermediate space 6 feet 5½ inches, and each side-space 8 feet 6½ inches in width, respectively; the top-width of embankments being 33 feet.

The rails are of the fish-bellied form, weighing from 50 to 52 lbs. to the yard lineal; the top-width is 2½ inches, the greatest depth 4½ inches, and the least depth 3½ inches; the thickness of the stem being ¾ inch. The rails, which are slightly inclined to the horizon, are set in chairs, and secured thereto by pointed pins, each pin having a perforation to receive a cross cotter, which is passed through it, and also through apertures in the feathers of the chair.

The first contract for rails was at the rate of 9*l.* 10*s.* a ton, and for chairs 6*l.* 15*s.* a ton. A second contract for rails was entered into at 13*l.* 10*s.*, and for chairs 8*l.* 15*s.* a ton, respectively. The rails and chairs were supplied from the Nant y Glo and Beaufort iron-works, South Wales.

Both blocks and sleepers are used on this way; the blocks are of Derbyshire millstone-grit, and contain each about 4 cubic feet. The joint-blocks ought to have been 2 feet 3 inches square, but very few contain 5 cubic feet. In the whole there are 36,960 blocks. The sleepers are of unkyanized larch, 9 feet long, and having a cross section of 9 inches by 4½ inches.

The ballasting is chiefly of broken stone, and partly of small coal for the upper layer.

The drainage consists of open cuts by the side of the railway, which are outside the fence. The fencing is of larch posts, with three rails.

STATIONS AND DEPÔTS.—The Sheffield station and depôt occupy ten acres of ground; that at Rotherham, 1½ acres; and that at the Greasborough canal, ¾ of an acre.

The Sheffield station has five lines of way passing under the carriage-shed, which is supported on three lines of cast-iron columns. From the main line a double siding passes through the locomotive engine-house, which is a building of neat appearance on the left of the way.

At Rotherham there are four lines of way under the passenger-shed, which is removed to a considerable distance from the booking-office, an inconvenience which is much felt by persons constantly using this railway, especially in bad weather. The shed is supported on three lines of cast-iron columns, and is altogether about 104 feet in length and 50 wide. Each line of way is terminated by a carriage-stop; and just beyond the shed is a cross line, running over four turn-tables, each 10 feet in diameter, and two of them having their rails projecting 2 feet 5 inches on each side. At the end of this cross line is a carriage-dock, the wharf-wall of which is 3 feet 6 inches high above the rails. This station is far from being well arranged; for passengers on their arrival and departure have either to cross the rails to get to or from the carriages, or to walk round beyond the end of the shed, which is, as we have before observed, a considerable distance from the booking-office and entrance-gates in Westgate.

The Brightside intermediate station is 2 miles, and the Holmes station $4\frac{1}{2}$ miles from Sheffield.

CARRIAGES.—There were originally three classes of carriages; but finding this arrangement did not succeed, the company have now only first-class and third-class carriages. The former are fitted up in the usual way, having three compartments, each holding six persons. The weight of a first-class carriage is about 3 tons 15 cwt., including four of Losh's wheels. There are six carriages of this description.

The third-class carriages, except two, are closed at top, and will hold each about forty passengers. These have cast-iron wheels with wrought tires, and weigh each about $2\frac{1}{2}$ tons.

The first-class carriages are painted yellow, and the third-class green.

The trucks are fourteen in number, with cast-iron wheels and malleable iron tires; the weight of each is estimated at 42 cwt.

The coal-wagons used on this line, except one, which is the property of the company, belong to Earl Fitzwilliam, the only coal-owner at present using this line. The weight of a coal-wagon is about 2 tons.

There is also one double truck, which will hold fifty sheep.

The passenger-trains consist usually of three carriages. The time occupied in the journey is about twenty minutes, including two stoppages of about one minute each.

The trains start from either end of the line fourteen times a day, except on Sundays, when there are nine trains from Sheffield and Rotherham respectively. Five of the trains daily in each direction are in connexion with those of the North Midland line, and on Sundays three.

The fares are, for a first-class passenger for the whole distance 1s., and for a second-class passenger 6d.; which are at the rates of 2·254d., and 1·127d. per mile respectively. The tickets are taken at starting.

The engines and carriages are reversed at Rotherham every trip by means of the turn-tables, to place them on the proper side for returning.

This railway was opened to the public on November 1st, 1838. During the first year the persons travelling by the trains amounted to 455,375; being on an average equal to nearly 1250 per diem, or about double the number calculated when the line was under the consideration of Parliament. During the six months of 1840, ending 30th June, the number of passengers amounted to 191,971.

LOCOMOTIVE ENGINES.—The locomotives used on this railway are six in number, and are chiefly mounted on six wheels; they were built by Messrs. Rt. Stephenson and Co., Messrs. Fenton and Co., Messrs. Bingley and Co., and Messrs. Davy, Brothers, and Co., of Sheffield. The wheels of those of Rt. Stephenson and Co. are without flanches, according to their improved construction. The tenders are calculated to hold each 600 gallons of water.

The coke used on this line is of a description suitable for making cast-steel: delivered at the station, it costs 13s. per ton. The consumption per annum is stated to be about 1046 tons.

THE ESTABLISHMENT.—Besides the secretary, the persons employed on this line are two collectors at Sheffield, two at Rotherham, and one for the Greasborough branch; eight police, four of whom attend to the gates at the level road-crossings, and two act as ticket-collectors at the intermediate sta-

tions of Brightside and Holmes; two smiths, two strikers, four engine-drivers, and three firemen.

RECEIPTS AND EXPENDITURE.—The receipts for passengers for the first eight months of the line being opened amounted to 8744*l.* 13*s.* 10*d.*, and for merchandise, &c. to 730*l.* 14*s.* 7*d.*; the former sum being equal on an average to 36*l.* 2*s.* 8·42*d.*, and the latter to 3*l.* 0*s.* 4·69*d.* per diem respectively.

The gross receipts for the above period amounted to 9475*l.* 8*s.* 5*d.*, and the disbursements to 5140*l.* 9*s.* 1*d.*; being equal to 54·26*l.* per cent on the gross revenue.

The sum received for passengers during the half-year ending 30th June, 1840, amounted to 525*l.* 4*s.* 9*d.*, for goods, &c. 688*l.* 18*s.* 8*d.*, and for coals 345*l.* 8*s.*; altogether, 1559*l.* 11*s.* 5*d.* Whereas the disbursements in the locomotive and coaching departments, and for maintenance of way, taxes, &c. for the same period, amounted to 1850*l.* 5*s.* 7*d.*; shewing a deficiency of 290*l.* 14*s.* 2*d.*

This railway was constructed under the immediate direction of Mr. Frederick Swanwick, a pupil of Mr. Stephenson, who was the engineer in chief during the progress of the works.

SLAMANNAN RAILWAY.

THE example set by some of the proprietors of lands on the line of the Slamannan Railway is indeed worthy of imitation. Instead of endeavouring to exact a large sum of money, as is too much the case with landowners similarly situated, these liberal gentlemen have actually presented to the company such portions of their estates as were required for the purposes of the railway.*

This line takes its title from the village of Slamannan, which is situate

* The names of these gentlemen are — Robert Jamieson, Esq., of Arden; Robert Haldane, Esq., of Auchingrey; and George Waddell, Esq., of Balquhatson.

in the upper part of the county of Stirling, and is distant from Glasgow in a direct line 15 miles, and from Edinburgh 27 miles; being in a north-easterly direction from the former city. The district around Slamannan is rich in coal and iron-stone; and by means of this railway, and the Ballochney, Monkland, and Garnkirk lines, and the Union canal, a direct communication is opened out between the mineral districts of Stirling and Lanarkshire and the cities of Edinburgh and Glasgow. Until the opening of this railway in the spring of 1840, the route from the coal-district already mentioned to Edinburgh was by the Ballochney and Monkland, and Kirkintilloch Railways, and the Forth and Clyde, and Union canals, being a total distance of 59½ miles; whereas by the Slamannan Railway and the Union canal, from Causeway End to Edinburgh, the distance is reduced to 35 miles 5 furlongs, thus effecting a saving in distance of 24 miles.

ACTS OF PARLIAMENT, &c.—The Act of incorporation received the royal assent on the 3d July, 1835, and authorised the Company to raise a joint-stock capital of 86,000*l.*, and by loan 20,000*l.* additional. In 1837 a second Act was obtained, dated 3d July, whereby authority was given to the Company to raise a further sum by shares of 29,000*l.*, making altogether 135,000*l.*

COURSE OF THE LINE.—From its junction with the north branch of the Ballochney Railway, the line takes a course nearly north-east, passing to the right and within a mile of Slamannan kirk, from whence it is produced to Avon bridge, and thence, following a curvilinear course, terminates on the Edinburgh and Glasgow Union canal, at Causeway End, which is distant from Edinburgh 23 miles 30 chains.

CURVES.—There are twelve curves, with radii of from 20 to 80 chains, or one mile.

INCLINATIONS.—The following exhibits the lengths and inclinations of the different planes, commencing at the Ballochney junction :—

chairs, the sockets of which are made to correspond exactly with the cross section of the rail, so that keys are entirely dispensed with. This method requires the chairs to be particularly well cast; and if this is attended to, we see no reason why this plan should not be generally introduced. Both stone blocks and wooden sleepers are used for the permanent way. The blocks are of whinstone, and measure from 20 inches to 2 feet square on the bed, and are from 10 to 12 inches in thickness; the cost of each block is 2s. 6d. The chairs weigh each 17 lbs., and are bedded on the blocks with an intermedium of Borradaile's felt. The chairs are secured to the blocks in the usual manner with $\frac{1}{2}$ -inch spikes, 6 inches long. The rails were supplied from the celebrated works of Messrs. Guest and Co., of Dowlais, South Wales, at 11l. 10s. per ton, delivered at Glasgow; the whole weight for the single way being 1000 tons, and the entire cost 11,500l. The chairs were furnished by Messrs. Murdoch, Aitken, and Co., of Glasgow, and cost 6l. 10s. per ton. The felt, delivered at Glasgow, cost at the rate of 70s. per 1000 pieces, each measuring 10 inches by 6 inches. The cost of laying the single way, including ballasting, is 5s. per lineal yard.

In passing over Arden Moss, for a length of $1\frac{1}{2}$ miles, the rails are entirely laid on longitudinal timbers of red pine, having a scantling of 10 inches by 4 inches. These timbers rest on cross sleepers of beech, larch, or Scotch fir, which are 9 feet in length, and have a cross section of 12 inches by 6 inches, being placed at intervals of 3 feet. The upper timbers are secured by means of screw-bolts, 8 inches in length, passing through from the chairs into the cross sleepers. The longitudinal timbers cost 2s. 3d. per yard lineal, and the cross sleepers 3s. 6d. each. None of the timbers are kyanized.

The ballasting consists of broken freestone, 10 inches below the blocks or sleepers, and filled up to the level of the top-surface of the blocks or sleepers, the upper layer being of whinstone, 6 inches thick, with gravel or quarry-rubbish.

The drains in the cuttings are 12 inches square, and built of stone, causewayed in the bottom, and covered with flags.

The fencing consists of stob or post and rails, the posts being 4 feet high, and fixed at intervals of 6 feet, with two rails each, being 4 inches by 2 inches in substance. A quick hedge is planted along one side of each fence throughout.

The line was let in two contracts, in 1837, to Mr. John Marshall, of

Glasgow; and Mr. Michael Fox, of Edinburgh. The whole cost of this work is about 100,000*l.*, or at the rate of 8,128*l.* per mile; and when furnished with a second set of rails, the cost will be increased to 10,000*l.* per mile.

This railway, which promises to afford an exceedingly profitable investment, was laid out by Mr. M'Neill, who is chief engineer to the Company; and the immediate superintendence of the works has been entrusted to Mr. Thomas Telford Mitchell.

SOUTH-EASTERN RAILWAY.

SEVERAL different lines of railway have been projected between the metropolis and the south-eastern coast. Besides the railway between Reigate and Dover, which is at present in the course of execution, two other main lines were brought before the public—the one called the Kent Railway, the other the Central Kent. The intended course of the Kent Railway was by Greenwich, Woolwich, Dartford, Gravesend, Rochester, Sittingbourne, Faversham, and Canterbury, being, in fact, within a short distance of the present mail-road throughout; the whole distance from London being about 83½ miles, and the characteristic gradient *sixteen feet*; the aggregate length of level planes was equal to 12½ miles; and the whole length of tunnelling to about 1½ miles. There can be no doubt that as regards local traffic this would have been the preferable line; but the magnitude of the works, and the large estimated cost of the undertaking, added to the nefarious system adopted with regard to the subscription-list when before parliament, all tended to lower this project in public estimation.

The course of the proposed Central Kent line was intended to be by Lewisham, Lee, Eltham, Bexley, Foots Cray, North Cray, Wrotham, Maidstone, Lenham, Ashford, Canterbury, Stodmarsh, Preston, Ash, and Sandwich; and the termination at the river Stour, in the parish of Stonar, near Sandown Castle; the whole length of this route from London to the south-eastern coast being 83 miles 75 chains, and the ruling gradient 19·62 feet. It was

intended to carry the line throughout its whole course without tunnelling; but the earthworks would have been very formidable. An example may be mentioned. The cutting at Wrotham, according to the parliamentary section, was shewn as $4\frac{1}{2}$ miles in length, and *averaging* 50 feet in depth.

As it is, the South-Eastern Railway has been chosen; and an excellent line it will, no doubt, prove in itself, both as regards the stability of the works, and the easy working of the locomotive engines, owing to the comparative absence of curves. Nor are the gradients, although within the second class, objectionable. We repeat in this page, what we have already urged in the course of this volume, that it is far more desirable to keep down the cost of construction, at the expense even of third-class gradients, if necessary, than to incur a vast outlay by an excessive amount of earthworks for the purpose of reducing the annual cost of locomotive power.

COURSE OF THE LINE AND GRADIENTS. — Leaving the Brighton Railway at Redstone Hill, at a point two miles south of Merstham, with a curve of about $\frac{1}{4}$ of a mile radius, the line proceeds for upwards of seventeen miles nearly in a direct course as far as Tunbridge, passing in this length on the north of Edenbridge and Chiddingstone, and close to Bough Beach. From Tunbridge town, which is close on the north side of the line, the course is direct by Tudeley to Marden; from whence the line is rectilinear as far as Headcorn, which is close on the north of the line; from Headcorn it pursues a straight course to Ashford, and falls, by a slightly curving course, into a south-eastern direction; passing to the west of Mersham, where, with a curve of three miles radius, it falls for a short distance into a course about east by south; passing thence on the south of Stanford, and continuing in a slightly curving course to Folkestone and Dover; the whole length from the Brighton junction at Reigate being 66 miles 20 chains, and from the London terminus of the Greenwich Railway 87 miles 43 chains.

The characteristic, and indeed the ruling gradient, is twenty feet, which is the same as that of the Brighton line; a circumstance highly advantageous in the event of the South-Eastern locomotives passing over the Brighton line to London.

Leaving the Brighton Railway at Redstone Hill, which is the principal summit of the line, the first dip is made to a point between Tudeley and

Marden, 25 miles distant; the whole fall of this reach is 225 feet. The second reach extends for a length of 30 miles, rising to the Standford summit, altogether 194 feet 9·96 inches. The third reach descends to the Dovor terminus, falling from the second summit 236 feet 9·96 inches, and being 245 feet 10·08 inches below the principal summit, or western terminus.

EARTHWORKS, TUNNELS, &c.—For the purposes of construction, Mr. Cubitt, the chief engineer, has divided the line into four districts, viz. the Godstone district, which extends from the Brighton junction to Bough Beach, a distance of 13 miles 70 chains; the Tunbridge district, extending from Bough Beach to the town of Marden, a length of 15 miles 60 chains; the Ashford district, which reaches from Marden to Grove Bridge, in the parish of Sellinge, the distance between these points being 23 miles 10 chains; and lastly, the Dovor district, extending from Grove Bridge to Dovor, which is 13 miles 40 chains in length.

In the Godstone district the earthworks are not peculiarly heavy; but there is one tunnel in the parish of Bletchingly 1080 yards in length, which presents a considerable proportion of heavy work. Mr. Cubitt estimates the whole of the works in this district at 248,405*l.*, or at the rate of 17,948*l.* per mile. Mr. F. Simms is resident engineer in this district.

In the Tunbridge district the principal earthworks are the Leigh cutting, formed with slopes of $1\frac{1}{2}$ to 1, and the river Medway embankment, having slopes of 2 to 1; the former containing 513,427, and the latter 588,118 cubic yards respectively. The produce of the Leigh cutting, which consists chiefly of hard white sand, with a proportion of marl, is carried to form the Medway embankment, the average lead being about $1\frac{1}{2}$ miles. To shew the nature of this material, it is only necessary to mention that it requires 100 lbs. weight of powder* to move 1000 yards of the sand.

There is one short tunnel in this district, which is situate at White Port, near Penshurst; its cross section is circular, the diameter being 25 feet. It is lined throughout with brickwork, the arch being 1 foot $10\frac{1}{2}$ inches in thickness.

* The powder costs 4*l.* 6*d.* per barrel of 100 lbs. weight, which is equal to 4·98*d.* per lb.; and the cost per yard moved is at the rate of 498*d.*

Mr. Barlow, Jun., the able and intelligent resident engineer at Tunbridge, informed us that the cuttings between Bough Beach and Ashford, a distance of 31 miles, amounted to 1,739,902 cubic yards, or at the rate of nearly 56,126 yards per mile.

The bridges are built of brick. Those over the railway are 15½ feet high, and have a clear span of 30 feet; and for turnpike-roads cost about 1000*l.* each. The occupation-arches under the railway are 12 feet in width.

A considerable saving is effected in the bridge-building department by the use of moulded and burnt earthen copings, which are exceedingly durable, and by no means unsightly. This plan is also adopted on the Midland Counties Railway.

Mr. Cubitt's estimate for the works in the Tunbridge district is 302,091*l.*, or at the rate of 19,180*l.* per mile.

In the Ashford district the works are very light throughout. The estimated cost is 278,329*l.*, or at the rate of only 12,012*l.* per mile.

The works throughout the Dovor district, which were commenced on the 2d November, 1837, are of a peculiarly striking character, especially between Folkestone and Dovor. In addition to the Shakspeare and Abbot's Cliff tunnels, through the main chalk cliffs, each of about a mile in length, there is also a short additional tunnel, extending for a quarter of a mile; a viaduct across the valley at Folkestone of 100 feet in height; and a sea-wall of concrete, for about a mile in length, the top of which is 60 feet above the level of the sea; besides several deep cuttings in the Warren or under cliff, varying from 8 to 90 feet in depth.

To the geologist the excavations making in the Dovor cliffs afford ample scope for the exercise of his all-searching investigations; to the civil engineer, the works carrying on are replete with interest throughout, presenting in the distance of about six miles almost every variety of work which falls within the pale of railway-construction.

We cannot but congratulate the Company in having selected Mr. Wright, as the resident engineer, to carry out the works in this important district. The manner in which they have hitherto been executed reflects the highest credit on this gentleman. The most difficult part of the works in this district has already been overcome; the workmen being habituated to their task, the progress is naturally more regular; and there is every likelihood of the

railway from Folkestone to Dovor — by far the most difficult and expensive portion of the line — being executed within a trifle of Mr. Cubitt's estimate.

But we must enter a little more into detail with regard to the tunnels, which are carried on in a way differing from the usual mode of executing similar works.

SHAKSPERE TUNNELS. — The tunnels through the Shakspeare Cliff present a fair sample of the mode of execution adopted in this branch of the works of the Dovor district.

The Shakspeare tunnels are carried entirely through the chalk cliff for a length of 1430 yards, rising westward with an inclination of 1 in 264. Being within a short distance of the face of the cliff, it occurred to Mr. Palmer, originally engineer to this Company, that the simplest way of executing these works would be to drive galleries, at convenient intervals, from the front of the cliff up to the main tunnels. The objects gained by this method are the facility and expedition with which the work is executed, together with the important advantages of ventilation and drainage. The first operation was to run a bench or roadway along the face of the cliff; a work attended with considerable risk to the workmen, but which was successfully overcome.

The next proceeding was to sink the vertical shafts from the surface of the country, and run up the galleries from the face of the cliff. The vertical shafts are each of 6 feet diameter, and seven in number, and their average depth 180 feet. The seven adits, or, as they are here called, galleries, average each about 400 feet in length, and have a cross section of 6 feet in width by 7 feet in height; the fall of each from the tunnel to the face of the cliff being in the ratio of 1 in 176. Through each of these galleries the chalk excavated in the tunnels is carried by means of small tram-wagons to its mouth, and there discharged into the sea.

The double tunnel is readily executed by the methods already described. Each shaft is 12 feet wide in the clear, 19 feet high to the springing line of the Gothic arch, and 30 feet in extreme height. The two shafts are separated by a solid pier or wall of chalk 10 feet in thickness. The nature of the chalk is so variable in different parts of the work, that it has been found necessary to line about two-thirds of the whole length with brickwork: on the parts where this is resorted to, the brickwork is built in three half-brick rings,

with contreforts at every 12 feet in length, and which are carried up and stepped back so as to receive the weight of any flat beds of chalk that appear at all doubtful; thus relieving the arch from much of the weight which would otherwise bear upon it. The brickwork throughout is wedged up solidly to the chalk so as to leave no room for slips; and where the space is considerable, the interval is filled in with concrete.

Mr. Wright describes the nature of the chalk as varying considerably in different parts. At the eastern end it is exceedingly hard, and full of undefined organic remains; whereas at the western end it is of a very soft description, and consequently much more easily worked: moreover it possesses the peculiar property of forming hydraulic lime of excellent quality. The line dividing these strata is easily defined through the whole length of the tunnel, the dip being at a rather more acute angle with the horizon than the inclination of the tunnel. The hard chalk is the superior stratum.

SEA-WALL.—Leaving the Shakspeare tunnel, the railway is carried in front of the cliff by an embankment, supported throughout by a retaining wall next the sea, the whole being about three quarters of a mile in length, and in some parts crossing the sea at high water. The retaining wall is constructed of concrete, according to the method adopted by Mr. Wright in forming the sea-walls at Brighton; it is thrown into cases, which are removed from time to time as the concrete becomes hard; and thus an excellent substitute for stone blocks is readily provided.

ABBOT'S CLIFF TUNNEL.—Leaving the marine terrace above described, the railway enters a second tunnel through the Abbot's Cliff, which, however, is different in point of dimensions, and is of a single bore throughout. The mode of execution is precisely similar to that already described as followed at the Shakspeare tunnels. The whole length of this work is 2200 yards, the clear width 24 feet, and its height 25 feet. It will be lined with brickwork throughout. The vertical shafts and galleries are similar to those of the Shakspeare tunnel, the average depth of the former being about 380 feet, and of the latter about 400 feet.

MARTELLO TOWER TUNNEL, AND OTHER WORKS.—Emerging from the west

entrance of the Abbot's Cliff tunnel, the railway enters on the under-cliff or warren, an exceedingly rugged feature of country in the Dover district, extending for about two miles chiefly in cutting, which varies from about 8 feet to about 90 feet in depth. Towards the middle of this length there is a short embankment of about 45 feet in height.

The Tower tunnel, which is next entered, is only 616 yards in length; it is executed by means of vertical shafts, and the whole is lined with brick-work.

The total quantity of cuttings throughout the line amounts to 6,000,000 cubic yards, or at the average rate of about 90,909 yards per mile.

In January 1840 there were not fewer than a thousand men engaged on the works between Dover and Folkestone. Mr. Cubitt estimates the cost of the works in the Dover district at 438,032*l.*, or at the rate of 32,615*l.* per mile.

ESTIMATES.—In Mr. Cubitt's report to the Directors, dated November 11, 1839, he estimates the works, as given above, in the Godstone district, to amount to 248,405*l.*; in the Tunbridge district to 302,091*l.*; in the Ashford district to 278,329*l.*; and in the Dover district to 438,032*l.* Thus the whole cost of the works was estimated at 1,266,857*l.*, or at the rate on an average of 19,043*l.* 5*s.* 9·09*d.* per mile; but by the engineer's revised estimate of November, 1840, the whole estimated amount was reduced to 1,244,163*l.*

GAUGE OF WAY, &c.—The gauge is necessarily 4 feet 8½ inches, the same as that of the Brighton, Croydon, and Greenwich Railways, as this line forms one of the four links of the railway-chain between London and Dover. The width of cuttings and embankments is 36 feet; and the width of ballasting is 30 feet. The fencing consists of stout wooden posts with three rails. The width of land enclosed, exclusive of slopes, is 72 feet in the Weald, and 48 feet in the high country. The average cost of land in the Weald is about 70*l.*, and in the high country 200*l.* per acre respectively.

ACTS OF PARLIAMENT, &c.—The Act for the incorporation of the South-Eastern Railway Company received the royal assent on the 21st June, 1836,

and authorised a capital to be raised in joint-stock of 1,400,000*l.*, and by loan 450,000*l.* additional, together 1,850,000*l.* In the years 1837, 1839, and 1840, the Company obtained powers by amended Acts to make several deviations from the line as originally laid out. The principal deviations of 1837 were at Godstone, at Oxted, and at Dovor. Instead, however, of the line running by Godstone and Oxted, it is now considerably to the south, leaving the Brighton railway at Redstone Hill at a point opposite Reigate, whereby two expensive tunnels were avoided; but the distance from London is in consequence increased by about seven miles. By the Act of 1839, which is dated 19th July, the Company obtained power, *inter alia*, to make the deviation from Bough Beach to Redstone Hill above referred to, whereby the line is rendered nearly straight from Reigate to Ashford, a distance of upwards of 40 miles. The whole number of shares is 28,000 of 50*l.* each.

ARRANGEMENT WITH THE BRIGHTON COMPANY.—By the first Act of 1839, which received the royal assent on the 14th June, the arrangement between the Brighton and South-Eastern Companies as to that portion of the Brighton line between the Croydon junction and the point of divergence of the South-Eastern Railway was entirely settled; the substance of which is, that when that part of the Brighton line which is to be used by both companies shall be entirely completed, the lower, or southern half shall be conveyed to the South-Eastern Company at cost price, with interest on the outlay; but each Company shall have the privilege of passing over the whole distance between the Croydon junction and the South-Eastern divergence, without either company paying toll to the other.

The Act of 1840, which received the royal assent on the 19th May, was for effecting a deviation in the line near Ashford.

The original parliamentary estimate for the whole line was 1,334,649*l.*; the entire distance from the Croydon Railway to Dovor being 69·512 miles, so that the average estimated cost per mile was at the rate of 19,200*l.*, whereas the present estimate for the works alone, independent of land, compensations, parliamentary and other expenses, &c. is at the rate of 18,779*l.* 16*s.* 4·12*d.* per mile.

RECEIPTS AND EXPENDITURE.—The whole amount received on account of

shares, interest, rents, &c. up to Nov. 26, 1840, amounted to 408,990*l.* 3*s.* 7*d.*, and the disbursements to the same period to 364,405*l.* 11*s.*

There can be little doubt but that, when this line is completed throughout, it will form the great highway from the British metropolis towards that of France, and indeed to the whole of southern Europe.

STOCKTON AND DARLINGTON RAILWAY.

THE Stockton and Darlington Railway afforded the first opportunity, on a sufficiently large scale, of testing the extraordinary powers of the locomotive engine. Here, too, the celebrated George Stephenson made his first appearance as a railway-engineer; and few lines since constructed have proved of greater use to the public at large, or yielded a larger return for the capital invested. The principal traffic on this line is in coal from the extensive Auckland field, whence it is conveyed to the places of shipment at Stockton and Middlesborough-on-Tees.

ACTS OF PARLIAMENT, &c.—The first Act for the construction of this railway was passed in the session of 1821, and empowered the Company to make a railway or tramroad from Stockton-on-Tees to Witton Park colliery, with several branches therefrom; and for this purpose to raise the sum of 82,000*l.* in 100*l.* shares, and 20,000*l.* by loan. In 1823 a second Act was obtained for the purpose of altering the course of the line, enlarging the powers of the Company, making an additional branch, and reducing the joint-stock capital from 82,000*l.* to 74,300*l.* In the following year a third Act was obtained, which empowered the Company to raise an additional sum of 50,000*l.*, and to substitute a new branch-line, nearly five miles in length, from St. Helen's Auckland up the valley of the Gaunless as far as Haggerleases Lane, for the originally intended branch to Evenwood Lane. A fourth Act received the royal assent on the 23d May, 1828, which empowered the Company to make the Middlesborough branch, and to raise an additional sum of 100,000*l.*

The capital in shares is altogether 150,000*L.*, and the whole amount raised by loan 100,000*L.*

GENERAL COURSE OF THE LINE.—The main line from Stockton to Witton Park colliery commences on the west bank of the river Tees, and proceeds in a south-western direction for about three miles, running for about $1\frac{1}{2}$ miles close to the turnpike-road to Darlington. It thence follows a more westerly course as far as Fighting Cocks, where it takes a quickly curving course northward, and recurves by Ripon House into a westerly direction, which it follows as far as Darlington, where, with a curve of about $\frac{1}{4}$ of a mile radius, it falls again into a northerly direction, passing by Whessoe, Whiley Hill, and Aycliffe, to Sim Pasture, which is the point of junction with the branch from the Clarence Railway. From Sim Pasture the line is traced by East Thickey to Shildon, which is the end of the locomotive portion of the line. It thence proceeds to the north of West Thickey, and passing between St. Helen's Auckland and West Auckland, continues to its termination near Witton Park colliery; the whole distance from Stockton being 25·379 miles.

Besides the main line there is the Middlesborough branch, 4 miles in length; that to Haggerleases Lane, nearly 5 miles long; the Black Boy branch, leaving the main line near East Thickey, 3 miles in length; and the branch to Yarm, $\frac{1}{2}$ of a mile long. The branch from Darlington to Croft Bridge has been purchased by the Great North of England Company, and become part of their railway. Thus the aggregate length of the main line and branches is 38·129 miles. There are some very quick curves on the main line, having radii considerably under a quarter of a mile in length.

LEVELS AND INCLINATIONS.—From Stockton the line rises 536 feet 1 inch to the first summit at the top of the Brussleton fixed-engine plane, which is distant from the eastern terminus 20 miles 47·17 chains. The bank-head is $3\frac{1}{2}$ chains in length, and rises 7 $\frac{1}{2}$ inches; the Brussleton west incline is 1 mile 4·74 chains long, and falls 165 feet 8 inches. The second or Etherly summit is reached in 3 miles 10·96 chains; the whole height gained above the Stockton terminus being 588 feet 9 inches. The next plane makes a dip of 100 feet for 51·59 chains to the bottom of the Etherly west incline, from whence the last plane rises 4 feet 4 inches to the western terminus, near Witton Park colliery.

In the first reach from Stockton to the Brussleton summit there are 18 planes, all ascending, with inclinations of 1 in $33\frac{1}{2}$, 1 in 104, 1 in 105, 1 in 128, 1 in 135, and 1 in 144; and from 1 in 144 to 1 in 2110 respectively. The Brussleton eastern incline of 1 in $33\frac{1}{2}$ is 825 yards, or 37·50 chains in length. The aggregate length of the inclines of from 1 in 104 to 1 in 144, is 6 miles 51·27 chains; and the inclines of 1 in 104 and 1 in 105 are of the respective lengths of 2042 and 3102 yards. The second reach is the Brussleton west incline, 1 mile 4·14 chains in length, which descends at the rate of 1 in $33\frac{1}{2}$. The third reach is 2 miles 28·86 chains long, and rises in three planes to the Etherly summit, with inclinations of 1 in 576, 1 in 176, and 1 in 34, which last is worked by the Etherly fixed engine. The fourth reach is the Etherly west incline, 50·40 chains in length, which descends at the rate of 1 in 33. The last reach is 32·81 chains in length, and ascends at the rate of 1 in 500.

This line comes under the second class in point of gradients.

BRIDGES, &c.—The number of bridges on the main line between Stockton and St. Helen's Auckland, a distance of 22·30 miles, is 24, of which thirteen are under and the remainder over the railway. The level road-crossings between the same points are fifteen in number. In the autumn of 1839 there were no gates put up at the level road-crossings, but merely signal-posts at short distances from the point of intersection, with the word "signal" painted in conspicuous letters on a square board at top. The level field or occupation-crossings are sixty-eight in number. There are also 16 traverses and 7 sidings. On the Middlesborough branch there are two bridges under the railway, one level road-crossing, and eight level field-crossings. The earthworks are by no means heavy. The slopes of some of the embankments towards the summit of the line are planted with firs.

GAUGE OF WAY, &c.—The gauge is 4 feet $8\frac{1}{2}$ inches, and the intermediate space 5 feet in width; the side-spaces vary considerably in different parts of the way.

The rails originally introduced on this line were of fish-bellied form, weighing only 28 lbs. to the yard lineal; afterwards 35-lb. rails were laid down, but which have been removed, and heavy rails, chiefly 64 lbs. single parallel, substituted throughout (see Plate 3, fig. 61); they are set in chairs similar to

those in use on the Great North of England Railway (see pages 140 and 141). The chairs are secured by oak pins to stone blocks and wooden cross sleepers, and also to wooden blocks; the last-mentioned plan is peculiar to this railway. These blocks are of elm, measuring 2 feet by 1 foot 3 inches, and 6 inches in thickness.

The ballast is chiefly of small coal. Open side-drains are used throughout the works.

The fencing consists chiefly of wooden posts with two, and in some places three rails, and a quick hedge on the inside; some portions of the wooden fencing are coated with tar.

The distances are marked on mile-standards of stone, at intervals each of a quarter of a mile.

On one side of the railway small cots are erected for the use of the workmen employed on the line,—a plan which will, no doubt, very soon be followed on all the chief lines in the kingdom. These buildings are erected at small expense, and are very convenient for the waymen, and others at work on the line, who ought to be always near their work, and are thus prevented from frequenting the country ale-house.

STATIONS AND DEPÔTS.—The principal stations are at Stockton, Middlesborough, Darlington, Shildon, and West Auckland; besides which there are the following intermediate stopping-places—the Middlesborough junction, the Yarm junction, the Fighting Cocks, and Heighington. The buildings at the several stations are very properly of an inexpensive character throughout, by which the saving of a very considerable outlay has been effected.

The principal coal-depôts are at Middlesborough, Stockton, Darlington, and Shildon. At Middlesborough the arrangements for shipping the coals are on a very extensive scale; by means of drops the loaded wagons are let down into the vessels where the coals are discharged, and the empty wagons drawn up again. There are numerous lines of way at this depôt for the loaded wagons waiting to be shipped.

At Darlington the coal-depôt is situate on the west side of the great north road, and south of the railway, and is enclosed with stone walls. It consists of twenty-eight arched cellars, with openings in the roofs, ranged in two parallel lines; between which and on either side there is a roadway for common road-

wagons. Above each range of cellars, which are 27 feet in width, a single line of way is produced from the main line; so that the coals are readily discharged into the cellars* below by means of a flap in the bottom of each wagon. At the entrance to this depôt from Darlington there is a lodge, or weigh-house, with a six tons weighing-machine.

At the Shildon depôt, which is about 1,240 yards in length, there are numerous additional lines of way; altogether equal to 3,250 yards of single way, or upwards of $1\frac{1}{4}$ mile, in addition to the main double way. There are usually 1,000 wagons standing at this depôt.

CARRIAGES.—The coaches used on this line are of various descriptions. There are modern first-class carriages, in three compartments, each calculated to hold eight passengers; second-class carriages, open at the sides, and in three and four compartments, to hold thirty and forty persons respectively; mixed carriages, having one first-class and two second-class compartments; luggage-vans, with seats on the top to hold twenty-four passengers; and common-road coaches, railway-mounted: each coach has four wheels of 3 feet diameter, and as many springs 4 feet 6 inches in length, and consisting of twelve steel plates, weighing altogether 112 lbs.; the cost being at the rate of 7*d.* per lb.

Spiral-spring buffers are used with some of the best carriages. A first-class carriage weighs about 3 tons, and a second class 2 tons 12 cwt. A mixed carriage measures 14 feet 7 inches in length, 6 feet 9 inches in width, and 5 feet in height; the weight being about 2 tons 16 cwt. The framing of the carriages is of ash, and the panelling of mahogany; the lower frame is 5 by $4\frac{1}{2}$ inches in substance; the intermediate cross-pieces 6 by $3\frac{1}{2}$ inches,

* Cellars are appropriated for each description of coal brought down by the railway. The collieries from which the coals are transferred to Darlington are the Witton Park, belonging to Donald M'Clean, Esq.; the South Durham, G. Applegarth and Co.; Old Etherley Walls End, Harry Stobart and Co.; New Etherley Walls End, Jonathan Backhouse; Adelaide Walls End, Joseph Pease, jun.; Button Knowle Walls End, W. L. Prattman; St. Helen's Auckland Walls End, Joseph Pease, jun., and Co.; Tees Walls End, Jonathan Backhouse; Norwood Walls End, Durham County Coal Company; Seymour's Tees Walls End, Seymour and Co.; and Flintoft's, John Flintoft, Esq.

and the diagonal braces 4 by $3\frac{1}{2}$ inches; the whole being put together with white lead. The middle block is $13\frac{1}{2}$ inches long, 23 inches wide, and $3\frac{1}{2}$ inches thick. Some of the carriages are furnished with lateral foot-boards.

WAGONS.—The number of wagons in use on this line is about 5000, chiefly belonging to the coal-owners. The weight of a coal-wagon is 27 cwt. The wheels are of cast iron, chiefly of Hawks's manufacture.

FARES, TRAINS, TRAFFIC, &c.—The fares for first-class passengers are at the rate of $2d.$, and of second-class passengers $1\frac{1}{2}d.$ per mile respectively.

The number of trains daily in each direction between Stockton and Darlington is six; three of which are first-class and three merchandise-trains, to which passenger-carriages are attached, but these are indeed usually very slow coaches; and between Stockton and Middlesborough there are twelve trains daily. There are also three trips made with passengers in each direction daily between Darlington and Saint Helen's Auckland. On this part of the line the carriages are drawn by locomotive engines as far as Shildon, from whence a single coach is drawn up the Brussleton east incline by a rope attached to the fixed engine* at the summit, let down the Brussleton west incline by gravity, drawing the rope out after it; and from the bottom of this incline the coach is drawn by one horse as far as St. Helen's Auckland, which is the termination of the line as regards the carriage of passengers. The Brussleton inclines are lighted at night by fire-lamps; each lamp is suspended by a chain passing over a pulley, so that it is readily raised or lowered at pleasure. In ascending the inclines each train is furnished with a cow or trailer, for stopping the train in the event of the rope breaking.†

In four weeks ending August 5, 1837, the number of passengers conveyed by the company's trains amounted to 28,853; and for a similar period ending December 4th of the same year, the number was 12,099; during four

* The signal from the bottom of the incline for starting the engine is given by means of a bell at the bank-head, with which a light rope is connected; and passing by the side of the way, in proper standards with small rollers, to the bottom of the incline, is attached to a drum of 5 inches diameter, which is easily turned by a handle fixed at one end of the axle.

† See description of Rankine's self-acting stopper, page 100.

weeks ending August 6, 1838, the aggregate number was 19,123. For one year ending October 1, 1838, the total number was 200,688, or at the rate, on an average, of 641·17 per working day; and from October 1, 1838, to July 1, 1839, the whole number was 185,993, or at the average rate of 792·47 per diem.

The tickets are taken from the passengers at the starting of each train.

LOCOMOTIVE ENGINES.—In the autumn of 1839 the number of engines in use on this railway was thirty; most of which were rough six-wheel coupled engines for leading the coal-trains. Although some of the locomotives at that time in use have since been disposed of, or become unfit for work, it may be as well to give an outline of the different forms of construction which have been adopted on this railway; and if we take the catalogue of 1839, we shall include almost every form of locomotive engine that has hitherto been brought into use:—

No. 1. *Locomotion*. This engine was constructed by Messrs. Robert Stephenson and Co., of Newcastle. It is mounted on six solid cast-iron wheels, with case-hardened tires; each wheel represents a disc with several circular perforations (see Plate 17) formed at equal distances from each other and also from the centre of the wheel. The six wheels weigh together about 54 cwt.; and each three are connected by two coupling bars, each of which is attached to the two contiguous wheels. The cylinder is half inside and half outside the boiler, and placed vertically, being of 10 inches diameter, with a 24-inch stroke. A fire-tube of 24 inches diameter passes from the furnace to the end of the boiler, and back again to the chimney, which is at the same end as the furnace, and is therefore called a return-tube.

No. 2. *Hope*. This engine, which has been remodelled, was built by Kitchen, of Darlington. It has six coupled wheels (as No. 1); vertical outside cylinders of 11 inches diameter, with a 20-inch stroke, and a return-tube of 26 inches diameter.

No. 3. *Black Diamond*, Lister, Darlington. Four solid wheels of 4 feet diameter; outside sloping cylinders of 10½ inches diameter, fixed at an angle of about 45°, with a stroke of 18 inches; the fire-box is of 2 feet 3 inches diameter, and the boiler is multi-tubular, having 107 copper tubes of 1½ inches diameter, and passing from the fire-box to the smoke-box. The net weight of this engine is 10 tons.

No. 4. *Diligence*, Timothy Hackworth, Shildon. Remodelled; six coupled wheels (as No. 1); outside vertical cylinders, 16-inch stroke, 106 tubes.

No. 5. *Royal George*. This engine was built by White, of Lumley Forge, near Durham, about twelve years ago, with four cylinders; but being found not to answer, was remodelled by T. Hackworth. It has six wheels (as No. 1); vertical outside cylinders of 11½ inches diameter, with a 20-inch stroke; single return-tube, which decreases from 26 inches at the furnace-end to 18 inches in diameter at the chimney-end.

No. 6. *Auckland*, Timothy Hackworth. Six wheels (as No. 1); outside sloping cylinders of 12½ inches diameter, and fixed at an angle of 22°, with an 18-inch stroke; single return-tube, formed of plate-iron.

No. 7. *Rocket*, R. Stephenson and Co. Six wheels (as No. 1); outside sloping cylinders of 11 inches diameter, placed over the centre wheels, with a 20-inch stroke, the piston-rod being attached on each side to the wheel nearest the chimney; single return-tube.

No. 8. *Victory*. Same as No. 5; remodelled at Shildon.

No. 9. *Middlesborough*. Same as No. 6.

No. 10. *Dispatch*, built by Thomas Hackworth, Soho, near Shildon. Six wheels (as No. 1); outside sloping cylinders of 14 inches diameter, with 18-inch stroke; multi-tubular boiler.

No. 11. *Beehive*, Timothy Hackworth. Same as Nos. 5 and 8.

No. 12. *Briton*. Same as Nos. 5, 8, and 11.

No. 13. *Coronation*,* Rt. and W. Hawthorn. Six coupled wheels (as No. 1); vertical outside cylinders 14½ inches in diameter, 16-inch stroke; boiler 13 feet long and 44 inches in diameter; 106 copper tubes, 4 feet long and 1½ inches in diameter, area of tubes 194·22 superficial feet; fire-tube 29 inches in diameter and 9 feet long, area of fire-tube 71·10 superficial feet; chimney 14 inches in diameter. Gross weight of engine, 11 tons 15 cwt.; net weight, 10 tons 5 cwt.

No. 14. *Tees*, Kitchen. Same as No. 11.

No. 15. *Tory*. Same as No. 6. The cost of an engine of similar

* Messrs. Hawthorn built five other engines of similar construction to No. 13 for this company, which were called *Majestic*, *William the Fourth*, *Northumberland*, *Lord Brougham*, and *Shildon*.

construction to *Auckland* or *Tory*, is 1000*l.*, and if furnished with a multi-tubular boiler, 1200*l.*

No. 16. *Director*, Rt. and W. Hawthorn. Same as No. 13.

No. 17. *Whig*, Kitchen. Same as Nos. 6 and 15.

No. 18. *Swift*, Rt. and W. Hawthorn. Same as Nos. 13 and 16. This engine was sold to the Great North of England Company in September 1839.

No. 19. *Darlington*, Rt. and W. Hawthorn. Six wheels (as No. 1); 14½-inch outside cylinder, 16-inch stroke; boiler 51 inches in diameter and 9·75 feet long; 89 tubes of 1½ inches diameter, the area of tubes being equal to 326·14 square feet; fire-tube 29 inches in diameter and 9·50 feet long, its area being equal to 86·50 square feet. Gross weight, 11½ tons; net weight, 10½ tons.

No. 20. *Adelaide*, Rt. Stephenson and Co. Same as No. 13.

No. 21. *Earl Grey*, Rt. and W. Hawthorn. Same as No. 19.

No. 22. *Lord Durham*, Hawthorns. Similar to No. 19.

No. 23. *Wilberforce*, ditto, ditto.

No. 23. *Magnet*, T. Hackworth. Six wheels (as No. 1); 15-inch vertical inside cylinders, 16-inch stroke; 110 tubes 7 feet 6 inches long, and 1½ outside and 1½ inches inside diameter; fire-tube 2 feet in diameter at furnace-end. The small tubes are arranged over and around the fire-tube, and the latter is divided in the middle by a 4-inch wall built of fire-bricks and fire-clay.

No. 25. *Enterprise*, Kitchen. Same as No. 2.

Besides the above, there were the *Queen*, the *Arrow*, the *Sunbeam*, the *London*, and the *Raby Castle*.

The *Queen*, built by Kitchen, and which is expressly for the coach-trains, is of more modern construction than those above described. It has six wheels, four of which are coupled, and are each of 4 feet 6 inches diameter, and two of 3 feet diameter; the cylinders are inside, and of 12 inches diameter, the stroke being of 18 inches; the boiler is multi-tubular.

The *Arrow* has four bearing wheels, each of 3 feet 6 inches diameter, and two driving wheels of 5½ feet diameter; inside horizontal cylinders of 9 inches diameter and 18-inch stroke; 135 tubes of 1½ inches diameter.

The *London*, built by Hague, of Cable Street, is mounted on four coupled wheels of Losh's construction, each of 4½ feet diameter; inside cylin-

ders of 10 inches diameter and 18-inch stroke; 2 tubes of 3 inches, and 72 tubes of $1\frac{1}{4}$ inches diameter respectively.

The *Sunbeam*, which is also a coach-engine, and built by Rt. and W. Hawthorn, is mounted on four wheels; two of 5 feet, and two of 4 feet diameter. Its gross weight is 9 tons 13 cwt., and net weight 8 tons 11 cwt. It has 12-inch inside cylinders, 18-inch stroke; boiler 38 inches in diameter and 8 feet in length; 104 tubes 8.33 feet long, and of $1\frac{1}{8}$ -inch diameter, the area of tubes being equal to 368.30 square feet; the fire-box is 28 inches long, $41\frac{1}{2}$ wide, and 38 high; the area of fire-box is equal to 42.07 square feet, the chimney being 14 inches in diameter.

The *Raby Castle* is a six-wheel modern coach-engine, built by Kitchen, of Darlington; and the *Dispatch* is also a new engine, built by T. Hackworth.

The depôt where the engines and repairs are carried on is situate at Shildon, near to the west end of that portion of the main line worked by locomotive engines. Four engines are usually stationed at Stockton, and one at Middlesborough.

The tenders of coal-engines consist of two water-butts fixed on wagon-frames, each of which will hold 600 gallons of water; besides which there is space for the fuel to be used on the journey; the whole being mounted on four wheels.

The coal-engines are limited in speed to six miles an hour; and if the engine-men are found driving at a velocity exceeding eight miles, they are invariably fined. At night a fire-lamp is suspended both in front and in the rear of each coal-train; and the approach of a train of coal-wagons is distinguished from that of a passenger-train by a bell, which is, or ought to be, sounded on nearing each level-road crossing, or approaching a station; the passenger-engines being furnished with the steam-whistle, according to the modern system. Yet we are of opinion that if several distinct sounds were introduced as signals to indicate different meanings, it would be attended with considerable advantage in the safe working of every railway where the locomotive engine is the principal moter.

The weight of the coal-trains on this line is necessarily regulated by the ruling gradient, which is 50.76 feet, or 1 in 104. The whole line ascends from the places of shipment to the collieries; the useful load is, therefore, entirely in the descending direction. The ascending trains

ordinarily consist of thirty empty wagons, the net weight of each being about 30 cwt.; so that the ascending load is equal to 45 tons, or 100,800 lbs. The number of coal-trains per diem averages through the year something like forty; the number of wagons in each train descending being about twenty-eight, on an average. Each wagon holds 53 cwt. of coal, so that the gross load of each descending train is equal to 116·20 tons, or 260,288 lbs. The average weight of coals daily descending from the collieries is thus equal to 2568 tons, or at the rate of 803,784 tons per annum. The charge for the conveyance of coal is at the rate of 2½*d.* per ton per mile for land sale, and 2*d.* a ton extra for wharfage, &c. when transferred to vessels at either of the shipping-places of Stockton or Middlesborough.

We found the average weight of four passenger-trains between Stockton and Darlington, in September and October, 1839, to amount to 40,270 lbs.; the average velocity to be 22·38 miles per hour; the highest velocity 37·50 miles per hour; and the stoppages to average each ·838 minute. Between Shildon and Stockton, on the 25th September, 1839, with a descending train weighing gross 17,496 lbs., we found the average speed to be 25·32 miles, and the highest speed 42·85 miles per hour respectively.

COAL, COKE.—For the coal-train engines coal is used; but with the passenger-trains, coke and coal mixed in equal proportions. The coke used on this line is prepared at the St. Helen's colliery, where there are sixteen ovens constantly in use. The operation of coking lasts forty-eight hours. The price of the coke, delivered at Darlington, is 10*s.* a ton.

The number of men to keep the double way in order is at the rate of about six per mile; the wages of each 3*s.* per diem.

When this line was first opened, the Company did not expect to derive much advantage from the carriage of passengers; by the numbers, however, carried daily, as shewn above, the income from this source must be very considerable.

The annual dividends, when the line was first opened, were at the rate of 4*l.* per 100*l.* share. They afterwards rose to 6*l.* and 11*l.* respectively; and during the years 1838 and 1839, they were at the rate of 14*l.* per share, from which amount the proprietors very wisely agreed to lay by 4*l.* towards a sinking-fund. The price of a 100*l.* share in 1839 was 260*l.*

STOCKTON AND HARTLEPOOL RAILWAY.

FEW railways have been executed in this country without the authority of an Act of Parliament; that, however, between Stockton and Hartlepool, recently opened for traffic, is one of the exceptions. The Company being able to purchase certain lands by private treaty, commenced operations without the delay necessarily attendant on obtaining an Act.

COURSE OF LINE.—Leaving the Clarence Railway in the township of Billingham with a curve of 50 chains radius, and half a mile in length, the line proceeds in a direct course for $3\frac{1}{2}$ miles; passing a little to the west of Cowpen, and through the townships of Cowpen and Greatham, it is produced with easy curvature through the townships of Greatham Hospital and Seaton Carew; thence close to the sea at New Stranton, and, verging on the east side of the Slake at Hartlepool, terminates on the south-western side of the Tide Harbour.

GRADIENTS.—The gradients, as will be seen by reference to the following table, are very favourable, and entitle this line to be numbered in this respect with the first class of railways. The following exhibits the lengths, levels, and inclinations of each plane:—

Total Distances.			Intermediate Distance.			Fall in this Length.	Gradients.	Feet per Chain.	Rate of Inclination.
m.	fur.	ch.	m.	fur.	ch.	feet.	feet.	feet.	
1	4	4·60	..	1	4	4·60	.. 24·167	.. 15·48	.. 1939 .. 1 in 341
5	0	6	..	3	4	1·40	.. —	.. —	.. level
5	4	5	..	0	3	9·00	.. ·833	.. 1·71	.. ·0213 .. 1 in 3087
6	4	5	..	1	0	0·00	.. 12·000	.. 12·00	.. ·15 .. 1 in 440
7	2	8	..	0	6	3·00	.. —	.. —	.. level
8	1	4	..	0	6	6·00	.. 2·540	.. 3·07	.. ·0385 .. 1 in 1715
Total ..			8	1	4	.. 39·54			

LAND.—The land is enclosed for a double way throughout, and varies from 14 to about 48 yards in width; the average width is above 28 yards. The total area of ground occupied by the railway and works is about

82½ acres, of which about 70 acres are enclosed lands; the remaining 12½ acres extend over the sea-sands below high-water mark, and a small proportion of the land was of no value for cultivation. For a considerable length the line passes through leasehold land; and "it is an usual custom with lessors in the county of Durham to reserve in their leases a right of granting a way-leave; and hence the practice has arisen of paying an annual rent (per mile in length of land passed through), instead of making an absolute purchase of the land. Many freeholders have adopted the same plan." A great proportion of the land taken for this railway is held according to this ancient custom.

FENCING.—About six miles are enclosed with posts and rails, and quick is planted for the same length on either side, and the remainder with fence-walls. The specification describes the wooden fencing to consist of larch posts 6½ feet long, and not of less scantling than $5 \times 2\frac{1}{2}$ inches; the posts to be 9 feet from centre to centre, with four rails of not less section each than $3 \times 1\frac{1}{2}$ inches.

EARTHWORKS.—The total amount of cuttings is 340,000 cubic yards, or upwards of 41,000 cubic yards per mile. For some distance the line runs close to the sea; and here the seaward slope, or face of the embankment, is of curvilinear form, and constructed of well-puddled clay, being united with the solid clay which underlays the sand. Its stability has already been subjected to repeated tests during many very heavy seas, which have washed over it again and again; but yet it continues to stand well, and a considerable quantity of sand and shingle are already deposited at the base of the slope.

GAUGE OF WAY, &c.—The original English gauge of 4 feet 8½ inches is necessarily adopted on this line, as it forms a junction with the Clarence Railway. The rails used are of the parallel form, in 15 feet lengths, weighing about 60 lbs. per yard lineal, and are required by the specification to be made of No. 2 mine iron, free from any admixture of cinder; the iron to be refined, then puddled; the puddled balls to be beaten under the shingling-hammer and rolled into bars; these bars to be cut down, piled and heated in the ball-furnace, and drawn into blooms under the shingling-hammer; the whole to be then reheated and

rolled into rails, being No. 3 iron when finished (see Plate 3, fig. 62). The rails are set in chairs with 3-feet bearings, in the usual manner, and secured to them by compressed oak keys; the intermediate chairs weigh each 18·30 lbs., and the joint-chairs 24·60 lbs. The chairs are chiefly secured to blocks of granite or other hard stone 2 feet square and 1 foot thick, except the joint-blocks, which are 3 feet long and 2 feet broad; each pair of joint-chairs is connected together by wrought-iron ties. The sleepers are of oak or larch, 8 feet in length, either semicircular in section (the diameter at the smaller end being not less than 10 inches exclusive of bark), or if of rectangular section, not less than 8 inches by 4 inches.

BRIDGES, CULVERTS, AND LEVEL CROSSINGS.—There are ten bridges under and over the railway, constructed chiefly of brick and stone; five of these are built askew. The largest of these arches are of 30-feet span, and are over the road to Greatham and the occupation-road to Eastfield Farm.

The culverts are ten in number, constructed of brick and stone, and vary from 2 feet to 25 feet in diameter. The largest culvert carries the Claxton Brook under the embankment at this place. The level road-crossings are thirteen in number, eight of which are for occupation-roads.

Although all the embankments and bridges, &c. are formed for a double way, a single line only is at present laid down, with about half a mile of double way at each end.

The cost of the whole, when finished, with a double line, is estimated by Messrs. Leather, the engineers under whom this work is executing, at 92,500*l.*, exclusive of land.

This line is worked by locomotive power. There are already two engines at work, which were constructed by Messrs. Rothwell and Co., of the Union Foundry, Bolton. The proportions of these engines are as follows, viz.: 13-inch cylinders, 18-inch stroke; two driving-wheels, each $5\frac{1}{2}$ feet in diameter; and four bearing-wheels, each of $3\frac{1}{2}$ feet diameter; 107 tubes, of 2 inches external diameter, and 8 feet $6\frac{1}{2}$ inches long; fire-box 2 feet 8 inches long, 3 feet 10 inches wide, and 3 feet 6 inches high; boiler 8 feet long, and 3 feet 4 inches in diameter; steam-passage $8 \times 1\frac{1}{2}$ inches; blast-pipe $2\frac{1}{2}$ inches diameter; chimney 5 feet 3 inches high above smoke-box, and 13 inches in diameter; the net weight of engine being 13 tons 4 cwt.

The chief traffic on this line will be in coals to be shipped at Hartlepool; but it will also afford a convenient communication for passengers between the termini. The works are executed in the most substantial manner, according to the usual practice of Messrs. George and John Leather, the engineers of Leeds.

WHITBY AND PICKERING RAILWAY.

WHEN the Liverpool and Manchester Railway was in course of execution locomotive engines were but in a comparatively infant state. In the report of Messrs. Walker and Rastrick, made to the directors of that Company as to the power to be employed in working their line, the speed for locomotive engines was fixed at *ten miles* an hour. Except, therefore, for the cause of humanity, comparatively little improvement would have been effected, as far as passengers were concerned, over the old mode of travelling by the horse-coaches, most of which were at that period worked at a speed of from nine to ten miles an hour.

The Whitby and Pickering Railway, in the North Riding of York, is entirely worked by horses, except for one short incline towards the summit, which is what is termed a self-acting plane.

ACTS OF PARLIAMENT, &c.—Two Acts of Parliament have been obtained by the Whitby and Pickering Railway Company; the former of which received the royal assent on the 6th of May, 1833, and authorised a capital to be raised in joint stock of 80,000*l.*, and by loan 25,000*l.*; and the latter received the royal assent on the 5th May, 1837, and empowered the Company to raise a further sum in joint stock of 30,000*l.*, making a total of 135,000*l.*

COURSE OF THE LINE.—The general course of this railway, which is very tortuous from end to end, is traced up the beautiful valley of the Eske. Commencing at Whitby on the west bank of the river and south side of the town, it passes through the parishes of Whitby, Lyth, and Middleton, and

terminates at Bakehouse Lane, Pickering. In its course it passes near Ruswarp Mill, Eske Hall, Chapel Ruins, Crowmond Abbey, and Beck Hall, where it leaves the valley, and is continued near to Goadland School-house and Raindall Mill.

CURVES.—There are several curves of about 20 chains or a quarter of a mile radius; and some of from 10 to 12 chains.

LEVELS AND INCLINATIONS.—In point of inclinations, it is altogether a very difficult line.

The rise from Whitby terminus to the summit, a distance of $11\frac{1}{2}$ miles, being not quite half way, is about 520 feet; and from the summit to the Pickering terminus the fall is about 434 feet.

Commencing at Whitby, the terminal plane descends at the rate of 1 in 808; thence succeed eleven planes, altogether ascending to the summit, with inclinations of 1 in 10·89, 1 in 28·38, 1 in 74, 1 in 107, and 1 in 117; the rest varying from 1 in 117 to 1 in 1691, the whole distance from Whitby to the summit being 11 miles 77 chains. The summit-level plane is $20\frac{1}{4}$ chains in length, from which to the Pickering terminus the whole line descends in thirteen planes, varying in inclination from 1 in 44·50 to 1 in 1056. The worst inclines in this reach have inclinations of 1 in 44·50, 1 in 55, 1 in 58·38, 1 in 68, and 1 in 77·28.

The whole length of this line is 23·962, or nearly 24 miles.

BRIDGES, TUNNEL, &c.—There is one short tunnel between six and seven miles from Whitby, which is 130 yards in length, 10 feet wide, and 14 feet high to the soffite of the semicircular arch or roof. The fronts are of neat design and good proportions, and are altogether built in the castellated style of architecture, which well accords with the thickly wooded scenery of the Eske.

The river Eske is diverted near to Whitby; and there are several bridges, chiefly of wood, crossing it in other parts of the valley. There are altogether about forty bridges and culverts, and four level road-crossings, which are of less consequence on this railway than on those worked by locomotives.

GAUGE OF WAY, &c. — The gauge of way is 4 feet 8½ inches; the intermediate space 5 feet 4½ inches; and each side-space 5 feet in width respectively, making the top width of embankment, where the line is double, 24 feet 5 inches.

The rails are of the fish-bellied form, in 15-foot lengths, weighing 35 lbs. to the yard lineal.

The chairs used are of the ordinary form, and are set on stone blocks in cuttings, and on transverse sleepers on embankments. In crossing over the wooden bridges the chairs are bolted down to the planking of the floor.

CARRIAGES.—The carriages are of two kinds, open and closed. The open carriages cost about 100*l.* each, and the closed 280*l.*, the latter weighing about 2½ tons. The wheels are of 3 feet diameter. Each carriage is drawn by one horse, as on the Edinburgh and Dalkeith Railway, the driver sitting in front, and having power to stop the carriage by a lever attached to the brake, conveniently fixed at the side of the carriage.

The wagon-bodies are constructed of wood, except the bottoms, which are of sheet iron. Each end can be removed at pleasure. The top length of one of these wagons is 8 feet 5 inches, and the bottom length 7 feet 9 inches. The width is 6 feet 2 inches, and the height above the soles 2 feet 6 inches; the sides are of 1½-inch deal. The soles project at each end 13 inches, and are 10 inches in depth; the whole being mounted on four wheels of 3 feet diameter, and furnished with springs. The net weight of a wagon is 34½ cwt. There are also trucks which weigh each 28½ cwt.

The most peculiar feature of this railway is the mode of working the inclined planes of 1 in 10·89 and 1 in 28·38, the two being contiguous: they are distant from Whitby about 8½ miles, and are together nearly a mile in length.

In order to assist the ascent of the trains, the traffic for each direction being neither equal nor regular, a preponderating load is provided on the top of the incline by means of a sufficient quantity of water, which is admitted into a tank properly constructed and mounted on railway-wheels. When the ascent of the wagons is effected, the water is allowed to run to waste at the bottom of the descending way. It is certain that this mode can be carried into effect only in very peculiar localities.

If such plan be adopted where locomotives are partly used, the water, provided it be of fit quality, may be brought into use a second time by being introduced into a tank at the bottom of the incline, and delivered therefrom into the tenders.

The rope-wheel, which is fixed horizontally at the top of the planes, is of 10 feet diameter, and 5 inches in depth, its rim being of hollow section to receive the $4\frac{1}{2}$ -inch rope, which runs on sheeves, placed at intervals of 8 yards all along the inclines. Where these planes are curved, the sheeves are fixed at different degrees of inclination, according to the position of each in the respective curves. Stone blocks are used as bases for the iron sheeve frames; and wooden vertical rollers are also introduced to afford the rope sufficient play where necessary.

This railway was laid out under the general direction of Mr. Stephenson; Mr. Frederick Swanwick, now of the North Midland Railway, being resident engineer during the execution of the works.

ULSTER RAILWAY.

THE railway from Belfast to Armagh is the first, and, in fact, at present, the only line in Ireland, the rails of which are laid to the gauge recommended by the Irish Railway Commissioners. It would, indeed, have been a fortunate circumstance had the question of gauge been fairly discussed and fixed at one standard in as early a stage of their introduction into Great Britain for the purposes of general traffic. As it is, we have a 7-feet gauge, a $5\frac{1}{2}$ -feet gauge, a 5-feet gauge, a 4-feet-8 $\frac{1}{2}$ -inches gauge, and a $4\frac{1}{2}$ -feet gauge. The ill consequence of this variety of widths between the rails will shortly be depicted in its true colours. We need not, however, in this page point out the particular localities, both in England and Scotland, which will suffer materially by this want of uniformity; but rather congratulate the Irish people on the introduction to their country of a national gauge, so that when railways shall become general in Ireland, which, by an economical system, is

THE FIRST PIECE OF RAILWAY Laid in Ireland.
It opened exactly eighty years ago to-day. It was on the 12th August, 1839, that railway communication between Belfast and Limerick was established.

exceedingly likely to be the case within a few years, the communication, except for six miles between Dublin and Kingstown, will be rendered complete throughout the kingdom by the general adoption of an uniform gauge of way.

ACTS OF PARLIAMENT, &c.—The Act for the incorporation of the Ulster Railway Company received the royal assent on the 19th May, 1836, and authorised a joint-stock capital to be raised in 12,000 shares of 50*l.* each, making a total of 600,000*l.*; and further empowered the Company to raise 200,000*l.* by loan, making together 800,000*l.* The number of shares is 11,196, the remainder having been forfeited.

GENERAL COURSE OF THE LINE.—Leaving the Belfast station in the Dublin Road, which is to the south-west of the Linen Hall, and distant from it about 400 yards, the line is traced in a curvilineal course to Dunmurry, keeping to the west of the mail-road from Belfast to Dublin, which it crosses at a distance of about five miles from the Belfast terminus; thence continuing to Lisburn, where it recrosses the mail road. From Lisburn it proceeds in a direction about west by south as far as Trummery, distant from Belfast about 13½ miles, from whence it is continued to within half a mile, and to the south, of Moira; beyond which, in a slightly curving course, it is traced to Lurgan and Portadown; thence, by a curve of three miles radius, falls into a direction about west by south; and recurving on the west of Loughgall, which is within about ¾ of a mile of the line, passes in a direct course to the southern terminus at Armagh; the whole distance being rather more than 36 miles.

CURVES.—The worst curves are at the Belfast station and at Lisburn; the former is of 21 chains, and the latter of 40 chains radius respectively. There is also one curve of 60 chains radius. The other curves are of a mile radius, and upwards.

INCLINATIONS.—In that portion of the line already opened to the public between Belfast and Lisburn, the inclinations and lengths of the planes respectively are as follows:—

Lengths of Firms.				Rate of Inclination.		Location.
Miles.	Chains.					
1	51-30	. . . . .	ascending	at the rate of	1 in 456	Downstream.
2	33-42	. . . . .	ascending	+	1 in 200	
1	06-53	. . . . .	ascending	+	1 in 264	
	44-25	. . . . .	descending	+	1 in 168	
2	00-00	. . . . .	ascending	+	1 in 254	Lisburn.
<hr/>						
7	60-00					

Thus it will be seen by the above that this line, in point of gradients, is within the second class of railways; the ruling gradient is 26·40 feet, or 1 in 200.

EARTHWORKS.—Owing to the sticky nature of the soil removed in the excavations of the Belfast district, the slopes, both of cuttings and embankments, are generally formed at 2 to 1. This material consists of a loose, soapy clay, that which there can scarcely be a more troublesome enemy to railway operations. Besides the increased expense of original construction, it requires an annual sum for several years after the opening of a line, to make good the slips into the cuttings and embankments. There are numerous illustrations of the above remarks in several of the English railways already opened to the public, including the London and Birmingham, the Grand Junction, the North Union, and the Durham and Sunderland, which are instances occurring to us at the moment.

The largest cutting is that of Farm Hill, the slopes of which are likely to cause considerable expense for some time to come. The temporary drainage, in September, 1839, was effected by means of a large wooden trough laid in the bottom.

Towards Lisburn the new red sandstone is intersected, and gravel is also met with. The average lead throughout was about $\frac{1}{2}$ of a mile; and the average cost of earthworks per cubic yard, 6s. 2d. The top-width of embankments is 33 feet; and of cuttings, from side-drain to side-drain, also 33 feet. The slopes are sown with grass-seeds.

BRIDGES, &c.—The bridges between Belfast and Lisburn are three in number. They are constructed of stone ashler, filled in with rubble; and

the arches of brickwork. The ashler, which is of sandstone, is worth 1*s.* 6*d.* per cubic foot, the whinstone rubble 7*s.* 6*d.*, and the brickwork 15*s.* per cubic yard respectively. The span of bridges over the railway is 28 feet, and their height 16 feet: the arches are semi-elliptical.

The bridge over the turnpike-road at Lambeg is on the skew principle: the arch is of segmental form, with a versed sine of 8 feet, the angle of obliquity being 45°.

Besides the bridges, there are twenty 2-feet, five 3-feet, and two 4-feet culverts.

There are altogether six level highway-crossings, two level lane-crossings, and twenty-one level field or occupation-crossings. At the level high-road-crossings temporary lodges are erected, and gates are hung, which shut across the roads. The cost of a paved level-crossing complete is 16*l.*

GAUGE OF WAY, &c.—The gauge, as already noticed, is 6 feet 2 inches; the intermediate space, where the line is double, which at present occurs only at the stations, 6 feet 4 inches; and each side-space 7 feet 2 inches.

The rails are of the bridge-form (see Plate 3, fig. 63), in lengths varying from 15 to 20 feet, and weighing 53 lbs. to the yard lineal. They are wholly laid on longitudinal timbers of American pine, with a lateral inclination of $\frac{1}{16}$ th inch. These timbers have a cross section of 12 inches by 6 inches, being, in fact, half baulks. The rails were supplied from the well-known works of Dowlais, near Merthyr Tydvil, at 12*l.* per ton. Cross-sleepers are introduced, at intervals of from 10 to 15 feet, under the longitudinal timbers; these measure 10 feet in length, the joint-sleepers having a scantling of 12 inches by 4 inches, and the intermediate sleepers 8 inches by 4 inches. The rails are secured to the longitudinal timbers in the usual way by $\frac{5}{8}$ -inch screws, 5 inches in length, each weighing on an average 6 oz., and inserted at intervals of 16 inches. The rails, however, are not bedded on felt, according to the English custom; which we certainly consider injudicious, inasmuch as it forms a more compact bed than the wood, and certainly tends much to the ease of travelling; besides which the screws are less liable to displacement. The whole of the timbers are kyanized; the cost of this process being at the rate of 2*d.* per cubic foot, and the cost of the timber itself 1*s.* 8*d.* per cubic foot, cut to scantling. The cost of laying the permanent single way,

including timber, screws, bolts, labour, cartage, &c. was 20*s.* per yard lineal. The wages of masons employed on this work was 24*s.*, bricklayers 21*s.*, and carpenters 18*s.* per week respectively. The price of bricks was only 21*s.* a thousand, there being no duty on this building article in Ireland.

The ballasting consists of gravel and broken stone, for a depth altogether of 16 inches; the gravel being 12 inches in thickness.

The drainage is effected by lateral drains, cut at the bottom and top of each slope of the excavations. Rubble-drains are also introduced in the cuttings. Semicircular perforated tile-drains, 12 inches in length and 5 inches in diameter, are also used, which rest on 12-inch flat tiles. The whole cost of laying a thousand tiles is 25*s.*

The fencing consists chiefly of posts and two rails only, which, together with quick plantings and ditch, costs at the rate of 16*d.* per yard lineal. The field-gates are of wrought iron, and cost 50*s.* each.

The whole width of land enclosed for the railway is 57 feet, exclusive of slopes. The whole area of land between Belfast and Lisburn is 93*a.* 3*r.* 13*p.* English measure, or at the rate of 12·107 acres per mile; the total cost, including compensations, being 18,903*l.*, which is equal to 2,433*l.* 18*s.* 2·33*d.* per mile, or rather more than 201*l.* an acre.

STATIONS.—The stations opened to the public are at Belfast, at Dunmurry, and at Lisburn. The intermediate stations of Dunmurry and Lisburn are distant from Belfast 4 and 7½ miles respectively.

The Belfast station is rather on an extensive scale, occupying altogether 3½ acres of ground. The buildings fronting the Dublin road present rather an imposing elevation. The whole front is built with stone from Ardrossan, North Britain. In the rear of the offices is a large passenger-shed, enclosed on either side by a brick wall, and covered with three spans of roofing, which is supported intermediately by two rows of iron columns, 20 feet in height, each row consisting of sixteen in number. The clear width of the shed is 100 feet, and its whole length 240 feet. The platforms are each 26 feet wide, and 15 inches above the level of rails; and the whole is lighted by fourteen windows on each side. There are three lines of way at this station, each furnished with turn-tables, 16 feet in diameter. At the Lisburn station there is a double line of way for 16 chains in length.

CARRIAGE DEPARTMENT.—The carriages are of two classes, first and second. The first-class carriages are built with four compartments, each calculated to hold eight persons, or thirty-two in all. The inside fittings are similar to those of the Grand Junction and other English railways, but have three instead of two parting elbows on each seat; each elbow is 15 inches long at top, and $9\frac{1}{4}$ inches high. The space allowed for each passenger is 1 foot $10\frac{1}{4}$ inches wide by a depth of 18 inches; the height of each seat from the floor is $16\frac{1}{2}$ inches, and from the top of the stuffed seat to the roof 3 feet 6 inches; the width between the seats is 18 inches. The under carriage is furnished with buffing apparatus; and the whole is mounted on four wrought-iron wheels of 4 feet diameter, the gross weight being about $4\frac{1}{2}$ tons. These carriages were built by Mr. Wise, of Lancaster, and cost each 510*l.*; but they are evidently of too large a size for four wheels.

The second-class carriages are also in four compartments, and will hold altogether forty-eight passengers. They are open at the sides, but closed at the ends, and roofed in; lockers are fitted up under the seats. These carriages are mounted on four 12-spoked cast-iron wheels; and were partly furnished by Mr. Braby, of Stamford Street, London, and partly by Messrs. Dunn and Wise, of Lancaster; and were supplied at a price of 260*l.* and 230*l.* for each respectively.

The goods-wagons are each mounted on four of Losh's wheels of 4 feet diameter. The whole cost of one of these wagons, including the wheels, which are worth 55*l.* the set, is 115*l.*

LOCOMOTIVE ENGINES, &c.—The locomotive engines used on this line are from the noted works of Messrs. Sharp, Roberts, and Co., of Manchester. They are called the Express, the Fury, and the Spitfire. The following are the proportions, &c. of the Express and Fury, which are in every respect similar:—cylinders 13 inches, stroke 18 inches; boiler 42 inches in diameter, length 8 feet; tubes $1\frac{1}{8}$ -inch external diameter, 8·33 feet long, and 150 in number; area exposed to the contact of heated air 529·65 superficial feet; fire-box 40 inches long, 42 inches wide, and 36 inches high; area exposed to radiating caloric 49·52 square feet. Chimney 14 inches in diameter and 5 feet 10 inches high above the smoke-box; sectional area of steam-passage 12·18, and of blast-pipe 4·25 inches respectively; two driving wheels of 6 feet

diameter, and four bearing wheels of 4 feet diameter respectively; the net weight being $14\frac{1}{2}$ tons.

The Spitfire is in all respects similar to the above, with the exception of the cylinders and chimney; the former of which are 14 inches, and the latter is 15 inches in diameter respectively.

These engines cost each 1500*l.*, and the tenders each 260*l.* Each tender will hold 800 gallons of water and 20 cwt. of coke. The usual working pressure is 56 lbs. on the square inch. The average speed of the trains, in September 1839, we found to be about 25·43 miles per hour, and the stoppages to average each ·79 minute.

The number of trains daily in each direction during the autumn of 1839 was seven; the distance, therefore, run by the engines with trains daily was equal to $108\frac{1}{2}$ miles. The average gross weight of each train was about 40 tons, or 89,600 lbs.; the consumption of coke daily 2·642 tons. The gross weight of the seven trains was equal to 280 tons moved $15\frac{1}{2}$ miles, or 4,340 tons moved one mile; the consumption of coke was, therefore, equal to 1·36 lbs. per ton per mile. The cost of the coke being at the rate of 42*s.* per ton, the expenditure on this account per day will be 5*l.* 11*s.*, which is equal to 3,025*l.* 15*s.* per annum.

THE ESTABLISHMENT.—Besides the engineer, superintendent, secretary, and three booking-clerks, there are in the locomotive department one driver at 50*s.* a week; two firemen each at 24*s.* a week; six coke and water-fillers and cleaners at 10*s.* 6*d.* a week each; and two fitters.

In the coaching and other departments there are twenty-one police, each at 10*s.* a week; four porters, one guard, and two watchmen, besides about ten waymen, each at 10*s.* a week.

The signals adopted are similar to those in use on several of the English lines, being given by means of white and red flags.

The cost of that part of the line at present open between Belfast and Lisburn, $7\frac{1}{2}$ miles, will be nearly according to the following items:—

Proportion of general expenses for the distance of $7\frac{1}{2}$ miles, including Act of Parliament and law-charges, and for advertising,	} £8,000 0 0
printing, rent, furniture, &c.	

Lands and compensations	£18,903	0	0
Works, stations, &c.	£54,586	10	10
Iron rails, timbers, screws, &c.	14,741	3	4
Engines, carriages, and wagons, &c.	11,371	17	3
		80,699	11 5
		£107,602	11 5

Thus the cost per mile of the railway between Belfast and Lisburn, with one set of rails and furnishing, according to the above account, will be at the rate of 13,884*l.* 4*s.* 0·61*d.*

The receipts from traffic for one year and twenty days, from the opening of the line on the 12th August, 1839, to 31st August, 1840, amounted to 8,957*l.* 3*s.* 6*d.*, and the expenditure for the same period to 8,312*l.* 6*s.* 9*d.*; being equal to 92·86*l.* per cent on the gross revenue. It is to be observed, that in this gross amount of expenditure there is very properly included a sum of 940*l.* as a reserve for depreciation in the locomotives and carriage-stock. Thus the actual outlay is reduced to 82·31*l.* per cent on the gross revenue.

This line was originally laid out under the joint direction of Messrs. Bald and Woodhouse; Mr. Stephenson was afterwards appointed engineer; but the whole has been executed under the immediate direction of Mr. Godwin, who is now sole engineer to the Company.

YORK AND NORTH MIDLAND RAILWAY.

It was the custom about a century and a half ago for persons intending to make a journey from London to York to arrange all their worldly affairs previously to starting on so dangerous and tedious an expedition; and now what would be the surprise and delight of our ancestors, could they but be permitted to glide luxuriously in cushioned vehicles over the smooth surface of the rails between the metropolis and the ancient city of York in less than one-seventh part of the time formerly occupied by them in the journey!

By the commercial enterprise and union of four distinct private companies, this grand railway-chain has been successfully completed, and is now in active operation.

The York and North Midland Railway forms the shortest link of this communication; and commences at the station within the ancient city-wall, close to Toft Green, and within a few minutes walk of Micklegate.

GENERAL COURSE OF THE LINE.—Leaving York, the general direction of this railway is south-west. In its course it passes to the right of the Holy Trinity Church, intersects Hob Moor; thence passing on the right of the Dringhouses, Bond Hill, and to the left of Copmanthorpe, continues through the townships of Colton, Appleton, and Bolton Percy; crosses the river Wharfe between Great Ing and Dumber Ing in the township of Ulleskelfe, and on the west of Rose Farm, in the township of Church Fenton; thence passes through the township of Sherburn, in which a curved branch to join the Leeds and Selby Railway diverges to the east, beyond which the line passes under the Leeds and Selby Railway, and enters the township of South Milford; thence continues through the townships of Fryston and Lumbly, wherein another curved branch diverges northward to the Leeds and Selby Railway; thence taking a curvilinear course through the townships of Hiliam, Burton Salmon, Brotherton, Fairburn, Ferry Fryston, Ledstone, and Allerton, joins the North Midland Railway near the river Calder, between Whitwood and Low Farm, where it divides the parishes of Methley and Norman-ton;—the total distance from York being 23·137 miles. There is also a branch, 1 mile 60 chains in length, diverging in a westerly direction, to join the North Midland Railway, in the parish of Methley, $1\frac{1}{2}$ miles from the junction with the main line; and two branches to join the Leeds and Selby Railway, the one on the north, the other on the south side of that line; the former being 1 mile, and the latter $1\frac{1}{2}$ miles in length respectively. Thus the aggregate length of the main line and branches is 27·137 miles.

CURVES.—With little exception, the whole course of this railway is curvilinear; but the least radius is as much as 55 chains in length, and this is at the western junction with the North Midland Railway.

INCLINATIONS.—The inclinations throughout are exceedingly favourable, the steepest plane of the main line having a gradient of 10·09 feet, 16 feet being the maximum of the first-class gradients.

The plane, inclining with the gradient of 10·09, or 1 in 484, rises southward to the junction with the North Midland Railway at Normanton for a length of 1·375 miles.

The summit of the line is at the North Midland junction, the level of the rails at this point being 49 feet 9 inches above the York terminus. The line, however, makes a dip intermediately to Ulleskelfe, at a distance from York of 9·525 miles; the whole fall from the York terminus being 16 feet.

EARTHWORKS, BRIDGES, &c.—Taken throughout, the earthworks are very light, as the railway runs for a great proportion of its length very near the general surface of the country. The principal work in this department is the cutting at Fairburn, which is about 60 chains in length, and averages about 48 feet in depth. The slopes throughout are generally formed at 2 to 1; but some are at $1\frac{1}{2}$ to 1. They are covered with vegetable mould, and sown with grass-seeds. The top-width of embankments is 32 feet.

The number of bridges on the main line is 31, which is at the rate of about 1·34 per mile. The arches over the railway are of 30-feet span and 17 feet in height; and the width between parapets of bridges under the railway is 25 feet.

The principal works in this department are the bridges over the rivers Aire, Wharfe, and Calder.

The Aire Bridge carries the railway over that river at the division of the townships of Allerton and Methley. It consists of three brick arches, each of 56-feet span, and 3 feet in thickness, being of semi-elliptical form, with a versed sine of 18 feet 6 inches; the height from the surface of the water to the springing line of arches being 11 feet 6 inches. The piers are each 9 feet in thickness, and the extreme width to outside of parapets 29 feet. The points of piers or cutwaters project considerably beyond each face of the bridge. The total length of this structure is 265 feet. The cutwaters and general dressings are of Bramley Fall stone, and the rest of this bridge is of brickwork.

The Wharfe Bridge carries the railway over that river at the point of intersection of the boundary between the townships of Ulleskelfe and Bolton-

Percy. This structure is altogether 274 feet in length and 30 feet 4 inches in external width. It consists of one central semi-elliptical brick arch of 60-feet span and 3 feet in thickness, and eight semicircular land arches, each of 15-feet span and 18 inches in thickness. The middle piers are each 15 feet in thickness and 32 feet 6 inches long, and are founded on piles 10 feet long, and having a scantling of 9 inches by 9 inches. The arches, and indeed the structure generally, is of brick; and the cutwaters and dressings of Bramley Fall stone. The ordinary depth of water is 5 feet 3 inches; the highest level is 8 feet 9 inches.

The bridge over the Calder, which is near the North Midland junction, is built on the skew principle, and consists of three semi-elliptical arches, each of 50-feet span on the square, and 51 feet 9 inches on the skew, the versed sine being 17 feet. The arches are 3 feet in thickness, and the piers 8 feet. The clear width between the parapets is 27 feet. The ordinary depth of water is 12 feet. The height from the water's surface to springing line of arches is 13 feet. The whole length of this bridge is 263 feet. It is built of brick and stone, as the Aire and Wharfe bridges above described.

There is also a large bridge over the railway at Holdgate Lane, which is likewise on the skew principle, the chord-line being 42 feet 6 inches, and the versed sine 10 feet. The square span is 30 feet.

The cost of brickwork in these bridges is at the rate of 22*s.* per cubic yard, the bricks having been supplied at 25*s.* a thousand; and of Bramley Fall stone 3*s.* 6*d.* per cubic foot.

The wages paid to artificers employed on this railway were after the following rates per diem, viz. : masons and carpenters, each 4*s.* 6*d.*; bricklayers, 4*s.*; navigators, 3*s.* 6*d.*; and labourers, 3*s.* respectively.

The number of level road-crossings is 15. Gates are hung across the roads intersected by the roads on a level, which shut also across the railway when required. The field or occupation level crossings are 27 in number.

GAUGE OF WAY, RAILS, &c.—The gauge is 4 feet 8½ inches where blocks are used, and 4 feet 9 inches in those parts laid with sleepers; the intermediate space 6 feet 5 inches, and each side-space on embankments 8 feet 1 inch wide respectively. On bridges the side-spaces are each 4 feet 6 inches.

The rails are of the single parallel form, somewhat similar to those of

the Manchester and Leeds Railway (but have a chase on each side of the stem), measuring 5 inches in depth, and being $2\frac{1}{2}$ inches wide on the top-surface, and weigh $54\frac{1}{2}$ lbs. to the yard lineal. They are set in chairs with 3-feet bearings, and secured thereto by an iron pin passing through a perforation in a solid lateral projection of the chair, similar to those formerly in use on the Birmingham line. The chairs are fastened with 6-inch dry oak pins, either to Bramley Fall blocks, each containing 4 cubic feet, which cost 4*s.* each, or to cross wooden sleepers kyanized, the additional cost for which is 1*s.* a sleeper, of the ordinary length and scantling. Felt is not introduced between the chairs and blocks.

The ballasting is of sand or broken stone, 28 inches in thickness. The open lateral drains are 3 feet in width at top, and 1 foot deep. From the inner side of the drain to the bottom of the slopes of embankments, the space is 4 feet in width, the bank being 3 feet wide, and formed of the produce of the drain. Longitudinal perforated tile-drains are also introduced down the middle of the cuttings and embankments, with cross drains at intervals of $15\frac{1}{2}$ feet. These drains are formed of hollow drain-tiles, $7\frac{1}{2}$ inches wide and 6 inches high, the upper edges being placed downwards, and resting on flat 10-inch tiles (Plate 16, fig. 19).

The fencing consists of stout posts, with either three or four rails, but chiefly the latter number, there being only three miles enclosed with three-rail fencing.

STATIONS.—Besides the principal station at York, there are the following intermediate stations, with their distances respectively from the York terminus:—Copmanthorpe, 4 miles; Bolton Percy, $7\frac{1}{2}$; Ulleskelfe, $8\frac{1}{2}$; Sherburn, $12\frac{1}{2}$; Burton Salmon, $16\frac{1}{2}$; and Castleford, $19\frac{1}{2}$ miles respectively; the latter station being 4.70 miles from the Normanton station on the North Midland Railway. The stations on this railway are formed with a due regard at once to convenience and economy. At York the station is within the city wall, near Micklegate, and belongs jointly to this Company and that of the Great North of England Railway.

The coal-depôt, to which there is a double way from the York station, is situate on the south bank of the river Ouse, being about a quarter of a mile in length.

CARRIAGE-DEPARTMENT.—The carriages consist of first, second, and third class. The first class are of the ordinary form, in three compartments; each compartment will hold six passengers, as usual. The weight of a first-class carriage is 3 tons 14 cwt., the cost being 420*l*. They are furnished with lamps at night.

The second-class carriages are each in four compartments, and are calculated to hold altogether forty passengers. These carriages are open at the sides, the roofs being supported by upright iron standards, and the ends closed. The length of a second-class carriage is 16 feet, and the width 7 feet, the weight being 2 tons 19 cwt.

The third-class carriages are altogether open, but furnished very properly with seats, which are ranged lengthwise, four to each carriage. Each seat is 14 inches wide, and the space between the seats 18 inches. The whole width of carriage is 8 feet, and the length 12 feet 10 inches. The carriages are each mounted on four wheels, and furnished with buffing and traction-apparatus complete, similar to those on the Scotch railways and on the Stockton and Darlington line. There are also a few mixed carriages.

Each horse-box will hold three horses; its weight is 3 tons 5 cwt. The goods-wagons are of the ordinary construction, and weigh each 2½ tons. The coal-wagons used on this line weigh each 25 cwt. net, and will hold three tons of coal. The turn-tables are of 13 feet diameter.

FARES, TRAFFIC, &c.—There are five trains daily in each direction, and on Sundays three. The fares for first-class passengers are at the rate of 2·227*d*.; for second-class passengers, 1·764*d*.; and for third-class passengers, 1·323*d*. per mile respectively.

From 15th August to 9th Nov. 1840, inclusive, the number of passengers by the trains amounted to 70,523, which is equal on an average to 774·97 per diem. The gross receipts for passengers, parcels, &c. for the same period amounted to 11,413*l*. 6*s*., or at the average rate of 125*l*. 8*s*. 5*d*. per diem.

We found the average weight of six trains on this line in August and October 1839 to amount to 51,012 lbs.; the average velocity to be at the rate of 22·52 miles per hour; the highest velocity 35·71 miles per hour; and the stoppages to average each 1·16 minutes (see Table P. of Results of Practical Experiments, in the Appendix).

ACTS OF PARLIAMENT, &c. — The Act of incorporation received the royal assent on the 21st June, 1836, and authorised the Company to raise a capital in joint stock of 370,000*l.* in 7,400 shares of 50*l.* each, and an additional sum by loan of 123,333*l.*, together 493,333*l.* In the following year an amended Act was obtained, whereby the Company obtained powers to make several alterations in the line, and to reduce the capital to 335,000*l.* The number of shares is 6,700 of 50*l.* each.

The line was opened for traffic on the 30th May, 1839, to the Leeds and Selby junction; and throughout on the 1st July, 1840, at which time there were five trips daily in each direction, being the day appointed for the entire opening of the North Midland Railway. A further partial opening of the York line had, however, taken place about two months previously, extending the communication by railway from Sherburn to Burton Salmon, a distance of rather more than 3½ miles.

LOCOMOTIVE-ENGINE DEPARTMENT.—By reference to Table No. XXIV. of British locomotive engines, in the Appendix, the description and proportion of engines used on this line will be readily seen; they are all from the celebrated works of Messrs. Rt. Stephenson and Co., of Newcastle. The tenders will hold each about 564 gallons of water. The steam, when not required for the engine, is injected to the tank to raise the temperature of the water.

The principal engine-station is at York, not far from the passenger-station. It is a brick building, capable of holding six engines and tenders on two lines of way, which pass quite through it, and run from either end into the main line. This building is 34 feet 10 inches wide and 16 feet high. The archways at each end are each of 9 feet opening; the engine-pits are 4 feet wide and 3 feet deep. The brickwork is 18 inches in thickness; and the rails are laid on longitudinal baulks of red pine. The water-tank for the supply of the locomotive engines is elevated on an arched erection of brickwork at the north end of engine-house, which serves also as a store for coke. The tank is formed of cast-iron plates, bolted together in the usual way: its capacity is equal to 5,032 gallons. The coke, in 1839, was obtained from Shelfe, near Bradford, at 21*s.* a ton. A basket of coke holds 87 lbs.

The drivers on this line earn each 5*s.* a day of twelve hours; the firemen, 3*s.*; the coke and water-fillers, 3*s.*; and the fitters, 3*s.* 8*d.* respectively.

In the coaching and other departments the police earn each 17*s.*; the porters, 17*s.*; and the guards, 24*s.* a week each respectively, besides clothing in each case.

COST OF RAILWAY. — The following exhibits the various items of cost up to 30th June, 1840:—

Total expenditure up to end of 1837	£ 24,055	9	9
Lands and compensation	£ 66,501	0	9
Copmanthorpe enclosure	11	10	6
Tenant right	226	18	7
Rent of land	17	3	4
Redemption of land-tax	922	15	4
Old buildings	1,157	2	0
Surveying, &c.	476	13	0
		69,313	3 6
Earthworks, bridges, stations, &c.	199,474	10	2
Timber in sleepers, &c.	20,946	5	0
Kyanizing ditto	1,138	4	5
Iron rails, chairs, &c.	88,296	8	5
Wharfage at York	25	0	0
Labourers' wages	476	14	0
		310,357	2 0
Engines and carriages		20,081	12 6
Law-charges	5,747	13	0
Engineer-in-chief	3,171	15	0
Assistant engineers	1,011	17	0
Salaries	1,012	10	0
Direction	1,250	0	0
Police	105	1	6
		12,298	16 6
General expenses	2,580	16	5
Advertising, printing, &c.	1,038	7	11
		3,619	4 4
Interest on debentures		6,217	6 9
		£ 445,942	15 4

Thus the whole cost of the railway, up to the 30th June, 1840, was 445,942*l.* 15*s.* 4*d.*, or rather more than 16,214*l.* per mile; whereas the revised estimate in 1837 was at the rate of about 10,594*l.*

The disbursements in working the line, from the opening on the 30th May, 1839, to the 31st June, 1840, were as follows:—

Repairs of engines, and engine-drivers' wages	£ 1,308 11 9		
Coke	1,671 19 5		
Water and gas	112 2 10		
		3,092 14 0	
Police, porters, and clothing	1,460 7 1		
Salaries	425 18 5		
		1,886 5 6	
Mileage-duty	854 3 5		
Taxes and rates	231 17 11		
		1,086 1 4	
Compensation for loss of luggage and accidents by fire		93 2 4	
Sundry expenses and allowances	623 0 9		
Stationery, printing, and advertising	47 8 9		
		670 9 6	
Common-road coaching to Masborough		534 0 0	
		<u>£ 7,362 12 8</u>	

The receipts on account of passenger and goods traffic for the same period amounted to 23,127*l.* 8*s.* 2*d.*, so that the disbursements were at the rate of only 31·83*l.* per cent on the gross revenue. It must be remembered that being the first year there is no charge for maintenance of way.

This line was originally surveyed under the direction of Mr. Stephenson, who is still chief engineer to the Company. The works, however, have been very efficiently carried into execution under the immediate superintendence of Mr. Thomas Cabrey.

LEASE OF THE LEEDS AND SELBY RAILWAY.—In October, 1840, a lease of the Leeds and Selby Railway was granted to the York and North Midland and North Midland Railway Companies conjointly, for thirty-one years, at an annual rent of 17,000*l.*, payable quarterly clear of all deductions, and having precedence of claim over all dividends on the shares of the lessees' company. The lessees have power to purchase the Leeds and Selby Railway at the expiration of the term for 210,000*l.*

PRACTICAL RAILWAY EXPERIMENTS.

THE experiments described in the following pages were undertaken for the express purpose of shewing the every-day work performed by different kinds of locomotive engines on level planes, and also on ascending and descending inclined planes, graduated with first, second, and third-class inclinations. We have classified the different degrees of inclination, as affording a more easy mode of reference than that in ordinary use. According to our system, the maximum of the first class of gradients is sixteen feet, or 1 in 330; of the second class, fifty-two feet and eighty cents, or 1 in 100; and of the third class, eighty-eight feet, or 1 in 60. All inclines with gradients above eighty-eight feet belong to the fourth class.

Having the same object in view with regard to locomotive engines, we have also classified these machines according to their magnitude, and the gauge of way to which they severally belong. Thus the six-wheel engines for the seven-foot gauge,* as those on the Great Western Railway, belong to class A; the six-wheel engines for the Irish gauge to class B; the six-wheel engines for the new Scotch gauge to class C; the six-wheel engines for the five-foot gauge to class D; the four-wheel engines for the same gauge to class D 1; the six-wheel engines for the national gauge† to class E; the four-wheel engines for the same gauge to class E 1; and the American engines to class F.

An engine belonging to class A is shewn in elevation in Plate 1, the frontispiece; and sections and details of an engine belonging to this class are exhibited in Plates 7, 8, and 9.

Class B is represented by the "Novelty," an engine of recent design, shewn in Plate 6.

* See Plate 16, fig. 21.

† 4 feet 8½ inches.

An elevation of an engine called the "Victoria," at work on the Arbroath and Forfar Railway, and belonging to class C, is shewn in Plate 4.

Engines belonging to class E are shewn in elevation in Plates 4 and 5; the one is called the "Phoenix," built by Messrs. Edington and Son, of Glasgow (see Plate 4), and the other is Hawthorn's improved engine (see Plate 5), at work on most of the English railways laid with the national gauge.

Class E 1 is represented by the engine No. 1 of the London and Birmingham Railway in Plate 6.

The American engine "England," at work on the Birmingham and Gloucester Railway, and belonging to class F, is represented in elevation in Plate 6.

If the engines of any of the various classes have coupled wheels, the letter by which the particular class is distinguished is repeated. Thus the London and Birmingham goods-engines (an elevation, No. 90, is shewn in Plate 6) would be distinguished, as regards the classification, by E E 1; while a goods-engine belonging to class E (see elevation of "Albert," Plate 4) would be known by the letters E E only.

Each set of experiments is recorded in the alphabetical order of the railways on which they were made; and the experiments of each set in the order of their respective dates. They are distinguished as *general* and *particular*. In the general experiments the times were taken only at the starting from and arrival at each station; in the particular experiments the times were taken at each eighth, quarter, or mile interval, according to the division of distance adopted on the different railways; and on the Madeley inclines of the Grand Junction Railway, in the most particular experiments, the times were taken at intervals of 100 yards, which are shewn by wooden indicators having consecutive numbers painted on them.

The times were chiefly taken by means of a *velo-centimeter*, expressly made for this purpose. All the times were noted down in hours, minutes, and cents, which rendered the results much more accurate, and very considerably reduced the labour of calculation. In calculating the loads, each particular kind of railway-coach, with its net weight (see descriptions of railways), was noted down in tabular form, as also the average number of persons and horses carried the whole distance; together with the number and weights respectively of common-road carriages on trucks, &c. The average weight

of passengers was taken at 150 lbs., with an addition of 30 lbs. for luggage; and of horses at 900 lbs.

Except as regards the Leeds and Selby Railway, the proportions of the various locomotives used in the experiments are either shewn in the Tables of British Locomotive Engines, in the Appendix, or recorded in the description of the railways in the body of this work. The general results are exhibited in the Tables A to P, in the Appendix.

The railways on which the experiments were made are, 1. the Arbroath and Forfar; 2. the Birmingham and Derby; 3. the Dundee and Arbroath; 4. the Garnkirk and Glasgow; 5. the Grand Junction; 6. the Great Western; 7. the Leeds and Selby; 8. the Liverpool and Manchester; 9. the London and Birmingham; 10. the London and Croydon; 11. the London and South-Western; 12. the Newcastle and Carlisle; 13. the North Union; 14. the Stockton and Darlington; and, 15. the York and North Midland.

I. Arbroath and Forfar Railway.—Second-class gradients; locomotive engines, class C.

Experiment, No. 1 (particular). 12th Sept. 1839.—Heavy rain; from Arbroath to Forfar, ascending; distance, 15 miles; train consisted of one mixed coach, three second-class coaches, and two laden wagons; gross load, 59,930 lbs. Engine, Victoria (see Plate 4): average pressure of steam 45 lbs.; distance performed in 59·70 minutes; stoppages six, occupying altogether 8·25 minutes. The time of the train in motion was therefore 51·45 minutes, which gives an average velocity of 17·49 miles per hour. The highest velocity was on an acclivity of 1 in 1000, being at the rate of 23·07 miles per hour; on an acclivity of 1 in 438, the speed was at the rate of 20 miles an hour, and was reduced to 17·64 miles an hour on an acclivity of 1 in 240. About the intermediate stations the speed was reduced on an average to 12 miles an hour.

No. 2 (particular). Sept. 13, 1839.—From Forfar to Arbroath, descending; distance, 15 miles; train consisted of one mixed coach, three third-class carriages, six wagons, one large truck, and two small trucks; gross load, 65,010 lbs. Engine, Victoria: average pressure of steam, 45 lbs.; distance performed in 56·20 minutes; seven stoppages, occupying altogether 5·32 minutes. The time in motion was therefore 50·88 minutes, which is equal on an average to 17·68 miles an hour. The highest velocity was at the rate of 30 miles an hour, and occurred on declivities of 1 in 240 and 1 in 250; on a declivity of 1 in 1000, the velocity was at the rate of 21·89 miles, but it occurred at the approach to a stopping-place. The speed about the stopping-places was reduced on an average to 13·58 miles an hour.

No. 3 (particular). Sept. 13, 1839.—From Arbroath to Forfar, ascending; head-wind; distance, 15 miles; train consisted of one mixed coach, three third-class carriages, two wagons laden with coal, and one with lime; gross load, 65,790 lbs. Engine, Victoria: average pressure of steam, 42 lbs.; distance performed in 61·30 minutes; five stoppages, occupying altogether 5·10 minutes; time in motion, 56·20 minutes. The average speed was therefore 16·01 miles per hour.

No. 4 (*particular*). Sept. 13, 1839.—From Forfar to Arbroath, descending; rain, wind (in favour of train) from behind; distance, 15 miles; train, one mixed coach, three third-class carriages, two wagons with timber, one empty wagon; average gross load, 49,370 lbs.; four wagons were added half way, and the timber-wagons were taken off at Ley's Mill station, $5\frac{1}{2}$ miles from Arbroath. Engine, Victoria: average pressure of steam, 45 lbs.; distance performed in 58·75 minutes; six stoppages, occupying together 13·50 minutes. Time of train in motion, 45·25 minutes, giving an average rate of 19·88 miles per hour; the highest velocity was at the rate of 31·25 miles per hour, on a plane descending at the rate of 1 in 750; on the planes descending at 1 in 1000, the speeds were at the rate of 17·85, 20·68, and 23·80 miles per hour respectively.

II. *Birmingham and Derby Railway*.—First-class gradients, alternating in ascending and descending planes; locomotive engines, class E.

Experiment, No. 1 (*general*). 12th October, 1839.—Slight breeze; from Hampton to Derby; distance, 38·25 miles; train, three first-class and six second-class coaches, one carriage on truck; gross load, 83,288 lbs. Engine, Derwent, assisted for a short distance by a similar engine at starting: average pressure of steam, 55 lbs.; distance performed in 116 minutes; eight stoppages, occupying 22·75 minutes. Time in motion, 93·25 minutes, which gives an average speed of 24·61 miles per hour.

No. 2 (*particular*). 13th October, 1839.—From Derby to Hampton; weather fine, with side-wind; distance, 38·25 miles; train, two first-class, two second-class, and two third-class coaches, three luggage-trucks, one empty truck, one horse-box, and one horse; average gross load, 90,996 lbs. Engine, Derwent: average pressure of steam, $56\frac{1}{2}$ lbs.; distance performed in 121·36 minutes; seven stoppages, occupying together 15·72 minutes. Time in motion 105·64 minutes, giving an average speed of 21·72 miles per hour; the highest velocity was at the rate of 37·50 miles per hour, and was attained on an acclivity of 1 in 1077, and also on an acclivity of 1 in 440. For the quarter of a mile about each stopping-place the speed was reduced to an average of 10·89 miles an hour; on an acclivity of 1 in 723, steam shut off at ·80 minute before arriving at Burton station.

No. 3 (*particular*). December 5, 1839.—From Derby to Tamworth; slight breeze; distance, 23·25 miles. Train, two first-class, two second-class (open), and one second-class (closed) coaches, three trucks, two tons of coals; gross load, 62,312 lbs. Engine, Derwent: average pressure, 55 lbs.; distance performed in 59·02 minutes; three stoppages, occupying together 5·56 minutes. Time in motion, 53·46 minutes, giving an average speed of 26·09 miles per hour; the highest velocity attained was at the rate of 37·50 miles an hour on an acclivity of 1 in 1877. The speed in the quarter of a mile about each station was reduced to an average rate of 9·14 miles per hour; on level planes the highest velocity was at the rate of 33·33 miles per hour.

No. 4 (*particular*). December 5, 1839.—Slight breeze; from Tamworth to Derby; distance, 23·25 miles. Train, two first-class and four second-class coaches; gross load, 50,072 lbs. Engine, Burton: average pressure, 55 lbs.; distance performed in 76·80 minutes; three stoppages, occupying together 8·90 minutes. Time in motion, 67·90 minutes, giving an average speed of 20·10 miles an hour; the highest velocity attained was equal to 46·87 miles an hour on a descending plane of 1 in 447. On level planes the highest velocities attained were at the rates respectively of 26·78, 27·77, 30, 31·25, 35·71, and 37·50 miles an hour. The speed at the quarter of a mile about each stoppage was reduced to the average rate of 9·17 miles an hour.

No. 5 (*particular*). December 7, 1839.—From Derby to Hampton; distance, 38·25 miles. Train, two first-class, one second-class (closed), two second-class (open) coaches, one horse-box, one coke-truck with three tons of coke, two laden trucks, and one empty truck; average gross load, 71·944 lbs. Engine, Burton: pressure, 55 lbs.; distance performed in 114·80 minutes; six stoppages, occupying

together 13·69 minutes. Time in motion, 101·11 minutes, giving an average rate of speed of 22·69 miles per hour; the highest rate of speed was 37·50 miles an hour, attained on an acclivity of 1 in 402; on the level planes the highest velocities were 27·02, 28·84, 30, and 31·25 miles an hour respectively. The speed for the quarter of a mile about each stoppage was reduced to an average rate of 10·10 miles per hour.

III. Dundee and Arbroath Railway.—Nearly level; locomotive engines, class C.

Experiment, No. 1 (particular). Sept. 12, 1839.—Sea-breeze from east; from 3·62 miles from Dundee towards Arbroath; distance, 12·75 miles. Train, two mixed and four third-class coaches; gross load, 47,664 lbs. Engine, Griffin: average pressure of steam, 54 lbs.; distance performed in 42·70 minutes; four stoppages, occupying together 6 minutes. Time in motion, 36·70 minutes; average speed, 20·84 miles an hour; the highest velocity was at the rate of 35·71 miles an hour. At the quarter of a mile about each stoppage the speed was reduced to an average rate of 11·68 miles an hour.

No. 2 (particular). Sept. 13, 1840.—Strong sea-breeze; from Arbroath towards Dundee; distance, 13·50 miles. Train, three first-class, two third-class, and one third-class carriage with luggage compartment; gross load, 47,142 lbs. Engine, Fury: average pressure of steam, 54·33 lbs.; distance performed in 49·15 minutes; four stoppages, occupying together 6·56 minutes. Average speed, 19·01 miles per hour; the highest velocity was at the rate of 33·33 miles per hour. The speed at the quarter of a mile about each stoppage was reduced on an average to 10·68 miles per hour.

No. 3 (particular). Sept. 13, 1839.—Strong sea-breeze; from Dundee temporary station towards Arbroath; distance, 14·00 miles. Train, three mixed carriages and four third-class coaches, and one truck; gross load, 58,080 lbs. Engine, Fury: average pressure of steam, 54 lbs.; distance performed in 46·30 minutes; five stoppages, occupying together 6·78 minutes. Time in motion, 39·52 minutes; average speed, 21·25 miles an hour; highest velocity, 37·50 miles. The speed at the $\frac{1}{4}$ -mile distances about the stopping-places was reduced on an average to 9·80 miles an hour.

No. 4 (particular). Sept. 14, 1839.—Heavy rain; from Arbroath towards Dundee; distance 14·25 miles. Train, three mixed and two third-class carriages, and two luggage-trucks; gross load, 50,144 lbs. Engine, Rapid: average pressure of steam, 54 lbs.; distance performed in 43·30 minutes; four stoppages, occupying together 4·97 minutes. Average speed, 22·30 miles an hour; highest rate of speed, 35·71 miles an hour. Speed at the $\frac{1}{4}$ -mile about each stopping-place reduced on an average to 12·20 miles an hour.

IV. Garnkirk and Glasgow Railway.—Original Scotch gauge, $4\frac{1}{2}$ feet, not included in general classification; level for $5\frac{1}{2}$ miles from eastern terminus; black coal engines (see Table, No. IV. of British Locomotives, in the Appendix).

Experiment, No. 1 (particular). Sept. 3, 1839.—From Glasgow to Gartsherrie; distance, 8 miles. Train, three carriages; gross load, 15,360 lbs. Engine, Garnkirk: average pressure of steam, 50 lbs.; distance performed in 34·70 minutes; three stoppages, occupying together 1·87 minutes. Average speed, 14·62 miles per hour; highest speed, 30 miles per hour. Speed reduced on an average to 11·24 miles per hour at the $\frac{1}{4}$ -mile about each stopping-place.

No. 2 (general). Sept. 3, 1839.—From Gartsherrie to Glasgow; distance, 8 miles. Train, three carriages; gross load, 15,000 lbs. Same engine: average pressure of steam, 50 lbs.; distance performed in 29·67 minutes; three stoppages, occupying together 2·17 minutes. Average speed, 17·58 miles an hour.

No. 3 (*particular*). Sept. 4, 1839.—From Glasgow to Gartsherrie; distance, 8 miles. Train, three carriages; gross load, 14,640 lbs. Same engine: average pressure, 50 lbs.; distance performed in 30·44 minutes; two stoppages, occupying together 1·53 minutes. Average speed, 16·60 miles per hour; highest speed, 24·19 miles an hour. Speed about $\frac{1}{4}$ -mile in one instance, and $\frac{1}{4}$ -mile in the other, reduced to an average of 15·34 miles an hour.

No. 4 (*particular*). Sept. 4, 1839.—From Gartsherrie to Glasgow; distance, 8 miles. Train, five carriages; gross load, 24,100 lbs. Same engine: average pressure, 50 lbs.; distance performed in 32·50 minutes; three stoppages, occupying together 2·36 minutes. Average speed, 15·92 miles per hour; highest speed, 30 miles an hour. Speed reduced at $\frac{1}{4}$ -mile distances about stations to an average rate of 10·38 miles an hour.

No. 5 (*particular*). Sept. 4, 1839.—From Glasgow to Gartsherrie; distance, 8 miles. Train, four carriages; gross load, 19,640 lbs. Same engine: distance performed in 27·90 minutes; no stoppages. Average speed, 17·20 miles an hour; highest speed, 30 miles an hour.

No. 6 (*particular*). Sept. 4, 1839.—From Gartsherrie to Glasgow; distance, 8 miles. Train, four carriages; gross load, 19,280 lbs. Same engine: distance performed in 29·55 minutes; two stoppages, occupying together ·60 minutes. Average speed, 16·58 miles an hour; highest speed, 25 miles an hour. Speed reduced at $\frac{1}{4}$ -mile distances about stopping-places to an average rate of 6·84 miles an hour.

V. *Grand Junction Railway*.—First, second, and third-class gradients; line alternates in ascending and descending planes; locomotive engines, class E. On the Madeley inclines, besides the $\frac{1}{4}$ -mile standards, there are indicators of wood placed at every 100 yards; the distances being marked up the incline of 1 in 177, and down the incline of 1 in 265.

Experiment, No. 1 (*particular*). January 15, 1839.—From second mile-standard from Birmingham to Warrington; distance, 75·50 miles. Train, seven first-class carriages and two trucks; average gross load, 82,544 lbs. Engine, Eagle: distance performed in 226 minutes; five stoppages, occupying together 20·20 minutes. Time in motion, 205·80 minutes; average velocity, 22·01 miles per hour. The highest velocity was equal to 33·33 miles per hour, and occurred on the level plane beyond Hartford station. From the summit-level, descending to Crewe, the speed varied from 25·21 to 27·90 miles an hour; on the plane of 1 in 330, descending beyond Wolverhampton, the speed rose gradually from 16 to 30·76 miles an hour. The speed for the mile about each stopping-place was reduced, on an average, to the rate of 14·26 miles an hour.

No. 2 (*particular*). June 16th, 1839.—From Warrington to one-mile-standard from Birmingham; distance 76·50 miles; train, seven first-class coaches, two luggage-vans, one horse-box; average gross load, 95,312 lbs. Engine, Basilisk: distance performed in 196·15 minutes; five stoppages, occupying together 21·42 minutes. Time in motion, 174·73 minutes; average speed, 26·27 miles an hour. The highest rate of speed attained was 37·50 miles an hour, on the plane descending to near Stafford; on level planes the rates of speed were 25·75 miles, 26·66 miles, 30·00 miles, and 33·33 miles per hour respectively. Leaving Crewe, the speed was at the rate of 15·87 miles; on the plane ascending 1 in 330, it was 21·58 miles; on the succeeding acclivity of 1 in 265, it rose to 27·02; and by the time the train reached the top of the Madeley incline of 1 in 177, it had fallen to 23·07 miles an hour. On the succeeding plane of 1 in 330 the speed rose to 24 and 26·66 miles an hour respectively; and on the summit-level it reached 28·84 miles an hour. The average speed in the mile about each intermediate stoppage was reduced to 16·34 miles per hour.

No. 3 (*particular*). July 31st, 1839.—From Birmingham to Warrington; distance 76·50 miles; train, five first-class carriages, one horse-box, two horses; average gross load, 62,560 lbs. Engine, Shark: distance performed in 216·75 minutes; five stoppage, occupying together 17·02 miles per hour. Time in motion 199·73 minutes; average velocity equal to 22·99 miles per hour. The highest rate of speed attained was 33·33 miles an hour, on the plane of 1 in 265 descending towards Crewe; and on that descending towards Warrington, at the rate of 1 in 510. The highest velocity on the Madeley plane, descending at the rate of 1 in 177, was 30 miles an hour. On the declivity of 1 in 100, towards Warrington, the speed was at the rate of 30 miles an hour. At the mile about each stopping-place the speed was reduced, on an average, to the rate of 14·47 miles per hour.

No. 4 (*particular*). 30th August, 1839.—Rails greasy; from $\frac{3}{4}$ mile standard from Birmingham to Warrington; distance 76·75 miles; train, seven first-class coaches, two mails, two close and one open carriage on trucks, two horse-boxes, three horses, one truck; gross load, 131,532 lbs. Engines, Lynx and Prospero to Wolverhampton, Lynx and Eagle to Whitmore, and Lynx only to Warrington: average pressure of steam (Lynx), 55 lbs.; distance performed in 207 minutes; six stoppages, occupying together 33·66 minutes. Time in motion 173·34 minutes; average speed 26·56 miles per hour. Highest rate of speed, with the engine Lynx only, 42·85 miles an hour, descending Madeley incline of 1 in 177; and the same rate of speed was attained by the two engines Lynx and Eagle, on the plane beyond Wolverhampton, descending at the rate of 1 in 330, between the 70th and 80th mile standard from Liverpool, and also between the 76th and 77th mile-standards from Liverpool. In the $\frac{1}{4}$ -mile distances about the stopping-places the speed was reduced, on an average, to 13·66 miles an hour. On the plane between 25 and 27 miles from Liverpool, descending at the rate of 1 in 180, the speed was at the rate of 30 miles an hour; and on that descending at the rate of 1 in 100, at 25 miles from Liverpool, 37·50 miles an hour.

No. 5 (*most particular*). October 14, 1839.—From Stafford to Crewe; distance 24·20 miles; train, two mails, seven first-class carriages, one horse-box and two horses, three carriages on trucks; average gross load, 121,112 lbs. Engine, Medea: average pressure of steam, 56 lbs.; distance performed in 59·30 minutes; one stoppage, at Whitmore, occupying 4·55 minutes. Time in motion 54·75 minutes; average speed, 26·52 miles an hour. Highest rate of speed, 56·76 miles an hour, on the Madeley incline of 1 in 177, at indicator No. 13. The descent of the Madeley incline was commenced with a velocity of 28·40 miles an hour at indicator 59; and on approaching the declivity of 1 in 177, the steam being in a great measure shut off, it was equal to 34·09 miles an hour. The speed was reduced, at first, to 26·19 miles an hour, but rose very quickly to 42·61 miles an hour; afterwards, however, the prevailing speed was at the rate of 37·84 miles an hour, occasionally rising to 42·61 miles. At indicator 13, it reached the highest rate of speed, as already mentioned. Beyond this point to the bottom of the incline, the rates of speed varied from 30·96 to 48·69 miles an hour; on the incline of 1 in 265 the speeds varied from 28·40 to 48·69 miles an hour, 37·84 miles being repeatedly attained. The distance of 14,000 yards, measured by the indicators, or nearly eight miles, was performed in 13·67 minutes, giving an average velocity of 35·11 miles per hour.

No. 6 (*most particular*). 14th October, 1839.—From Crewe to Whitmore (ascending). As this experiment afforded the greatest results in ascending the Madeley incline, they are shewn particularly by a diagram (Plate 15), in which the vertical lines dotted represent the distances each of 100 yards; and the horizontal lines the rates of speed in miles per hour. Train, five first-class and two second-class coaches, one horse-box and two horses; gross load, 77,944 lbs. Engine, Vampire: average pressure of steam, 60 lbs.; distance, 10·45 miles, performed in 29·35 minutes; no stoppages. Average speed, 21·36 miles per hour; highest speed, 34·09 miles (see diagram).

No. 7 (*most particular*). October 14, 1839.—From Whitmore to Warrington; distance 34·25 miles.

Train, four first-class coaches, one carriage on truck, and three trucks; gross load, 61,504 lbs. Engine, Clio: average pressure of steam, 55 lbs.; distance performed in 73·30 minutes; two stoppages, occupying together 6·84 minutes. Time in motion, 66·46 minutes; average velocity, 36·92 miles an hour; highest velocity, 68·18 miles an hour, between 29th and 28th indicators. On making this descent, the speed of 37·84 miles was attained on 3800 yards, taken collectively. From indicator No. 61, top of the Madeley incline, the distance of 13,900 yards, or 7·89 miles, was performed in 13·06 minutes, which gives an average speed of 36·24 miles per hour.

No. 8 (*particular*). October 14, 1839.—From Birmingham to Hartford; distance, 65 miles. Train, one first-class, four second-class, two third-class coaches, three horse-boxes and four horses; gross load, 74,400 lbs. Engine, Oberon: average pressure of steam, 57½ lbs.; distance performed in 193·20 minutes; nineteen stoppages, occupying altogether 40·77 minutes. Time in motion, 152·43 minutes; average speed, 25·58 miles an hour; the highest rate of speed was 48·38 miles, on the declivity beyond Wolverhampton of 1 in 330: 46·87 miles an hour was the highest rate of speed in descending the Madeley incline of 1 in 177. The speed for the ¼-mile distances about each stopping-place was reduced, on an average throughout, to 12·59 miles an hour.

No. 9 (*most particular*). 14th October, 1839.—From Hartford to Stafford; distance, 35·75 miles. Train, two mails, six first-class carriages, two carriages on trucks; gross load, 95,984 lbs. Engine, Medusa: distance performed in 99·98 minutes; two stoppages, occupying together 12·80 minutes. Time in motion, 87·18 minutes; average speed, 24·60 miles an hour; highest speed, 38·46 miles, which occurred on the declivity towards Stafford of 1 in 505. In ascending the Madeley inclines, from indicator No. 46 on the lower incline to indicator No. 60 (near 52d mile standard from Liverpool), a distance of 10,600 yards, or 6·022 miles, the average speed attained was at the rate of 19·48 miles per hour; the time occupied being 18·54 minutes. The speeds at the ¼-mile distances about the stoppages at Crewe and Whitmore were reduced to an average rate of 20·56 miles an hour.

No. 10 (*particular*). November 13, 1839.—From Warrington to Crewe; rails greasy, with fog; distance, 24 miles. Train, two first-class, three second-class, and two third-class carriages; gross load, 61,840 lbs. Engine, Hecla: average pressure of steam, 55 lbs.; distance performed in 75·15 minutes; four stoppages, occupying together 10·78 minutes. Time in motion, 64·37 minutes; average speed, 22·37 miles an hour; highest speed, 40·54 miles, which was attained on the declivity of 1 in 338, at 26½ miles from Liverpool. The plane of 1 in 100 was ascended at the rate of 16·85 miles an hour; on level planes the average speed was about 21 miles an hour; and on descending planes of 1 in 330, about 26 miles an hour. The speed about the stoppages was reduced to an average rate of 15·58 miles an hour, which shews that the reduction in speed at the stoppages is in some degree proportionate to the average speed throughout; for by reference to the preceding experiments, where the average speed was above 26 miles an hour, the speed about the stoppages was reduced, on an average, to about 12 miles an hour.

No. 11 (*most particular*). November 13, 1839.—From Crewe towards Whitmore (ascending); distance, 10·03 miles; rails greasy. Train, six first-class coaches and two mails; gross load, 81·872 lbs. Engine, Alecto (in bad condition): distance performed in 27·60 minutes; no stoppages. Average speed, 21·80 miles an hour; highest speed, 34·09 miles ascending 1 in 177, shewing what can be done on acclivities by putting on the whole force of steam. The speed ascending this incline averaged about 24·50 miles an hour; whereas, on the incline of 1 in 330, at starting, and for the first mile and a half, the speed ranged from 7·55 to 23 miles an hour.

No. 12 (*most particular*). November 13, 1839.—From Whitmore to Crewe (descending); distance, 10·20 miles; rails greasy. Train, two mails, six first-class carriages, one carriage on truck; average gross load, 88,928 lbs. Engine, Lucifer: average pressure of steam, from Whitmore to near top of incline, 55 lbs.; distance performed in 16·60 minutes; no stoppages. Average speed, 36·86 miles an

hour; highest rate of speed, 68·18 miles an hour, which was attained between indicators Nos. 29 and 28, and again between indicators Nos. 27 and 26. The descent was commenced at a speed of 8·92 miles an hour, and increased rapidly to 48·69 miles, which was frequently attained during the descent both on this declivity and on those in continuation (1 in 265 and 1 in 330). The distance from indicator No. 61 at top of the inclines to indicator No. 79 at bottom of the inclines, being 14,000 yards, or nearly eight miles, was performed in 12·02 minutes, or at the average speed of 40 miles an hour. Yet with the excellent six-wheel engine, Lucifer, the motion was uniform and exceedingly pleasant; and we were enabled, single-handed, easily to note down the times at passing every indicator. The results of this experiment are also shewn in a diagram (Plate 15).

No. 13 (*most particular*). November 13, 1839.—From Crewe towards Birmingham (ascending Madeley inclines); whole distance, 48·25 miles. Train, four first-class, one second-class, and three third-class carriages, one carriage on truck, and one empty truck; average gross load, 75,696 lbs. Engine, Medea: average pressure of steam, 50 lbs.; distance performed in 128·36 minutes; three stoppages, occupying together 17·90 minutes. Time in motion, 110·46 minutes; average speed, 26·20 miles an hour; the highest rate of speed was 37·84 miles, which was attained between the indicators 46 and 45, on the acclivity of 1 in 265. Commencing the ascent of the Madeley inclines, the speed was at the rate of 14·20 miles an hour, and rose at times as high as 28·40 miles an hour; and when on the incline of 1 in 265, it varied from 22·72 to 37·84 miles an hour. On the upper acclivity of 1 in 177 it commenced at 26·19 miles an hour, rose to 34·09 miles at 1600 yards from its foot, and thence gradually fell to 17·04 miles an hour. As it reached the top, and on the acclivity of 1 in 330, approaching the summit, the speed was at the rate of 20 miles an hour. The ascent of the four planes for a total distance of 13,900 yards, or 7·89 miles, was accomplished in 19·88 minutes, giving an average speed of 23·86 miles an hour.

No. 14 (*general*). November 14, 1839.—From Birmingham to Whitmore; distance, 42·75 miles. Train, four first-class coaches, two mails, and one carriage on truck; gross load, 67,584 lbs. Engine, Oberon: distance performed in 96·70 minutes; two stoppages, occupying together 8·15 minutes. Time in motion, 88·50 minutes; average speed, 28·96 miles per hour.

No. 15 (*most particular*). November 15, 1839.—From Warrington to Whitmore; distance, 34·75 miles. Train, six first-class coaches, two mails, one horse-box and two horses; gross load, 89,272 lbs. Engine, Stentor (in bad condition): Camilla assisted up Madeley inclined planes: average pressure of steam (Stentor), 53 lbs.; distance performed in 103·65 minutes; two stoppages, occupying together 6·70 minutes. Time in motion, 96·95 minutes; average speed throughout, 21·50 miles per hour. The highest speed was 48·69 miles an hour, which was attained on the Madeley incline of 1 in 265, between the 38th and 37th indicators. The ascent of the acclivities (two engines) from indicator No. 80 at bottom, to indicator 61 at top, a distance of 14,100 yards, was performed in the space of 19·25 minutes, which gives an average velocity of 24·93 miles per hour.

No. 16 (*most particular*). November 15, 1839.—From Whitmore to Crewe, descending (see diagram, Plate 15); distance, 9·14 miles. No train. Engine, Camilla, with tender: average pressure of steam, 47 lbs. At starting, steam half on. Between indicators 62 and 61, at top of the inclines, the speed was equal to 42·61 miles per hour, but was lowered before reaching the declivity of 1 in 177, to 34·09 miles. During the descent of the incline of 1 in 177, the speed ranged from 34·09 to 48·69 miles, between indicators 18 and 17; and between indicators 12 and 11, on the declivity of 1 in 265, it reached 56·76 miles an hour; and between indicators 19 and 20, on the same plane, it rose to 68·18 miles an hour, fluctuating throughout considerably, as will be seen by the diagram already referred to. The whole descent of the inclines from indicator 62 at the top to indicator No. 77 towards the bottom, was effected in 14·08 minutes; the distance being 13,900 yards, and the average speed 34·02 miles per hour.

No. 17 (*general* to 32½ miles from Liverpool; *particular* from thence to Birmingham). Nov. 16, 1839.—From Warrington to Birmingham, strong head-wind; distance, 77·50 miles. Train consisted of Grand Northern Railway post-office and two mails, two first-class coaches; gross load, 45,628 lbs. Engine, Oberon: average pressure of steam, 57 lbs.; distance performed in 191·90 minutes; five stoppages, occupying together 25·56 minutes. Time in motion, 166·34 minutes; average velocity at the rate of 27·95 miles an hour; the highest velocity was equal to 39·47 miles an hour, and occurred on the level plane between 40 and 44 miles from Liverpool. On the Madeley incline (ascending at the rate of 1 in 177), the speed varied from 22·70 to 31·25 miles an hour. The whole ascent of the two inclines of 1 in 265 and 1 in 177 respectively, a distance of about 6·25 miles, was performed in 13·70 minutes, giving an average speed of 27·38 miles per hour, which is very nearly equal to the average speed throughout.

No. 18 (*most particular*). November 16, 1839.—From Birmingham to Crewe; distance, 70·50 miles. Train, five first-class coaches, two mails, and one carriage on truck; gross load, 78,256 lbs. Engine, Sunbeam: average pressure of steam, 55 lbs.; distance performed in 173·29 minutes; six stoppages, occupying together 24·60 minutes. Time in motion, 148·69 minutes; average velocity equal to 28·46 miles per hour; highest velocity, 68·18 miles an hour, which was attained on the upper part of the Madeley declivity of 1 in 177; and again on the succeeding declivity of 1 in 265. From indicator No. 61, at top of the Madeley inclines to indicator No. 79, at the bottom, near the Crewe station, the distance of 14,000 yards was performed in 12·14 minutes, giving an average velocity of 39·50 miles an hour.

No. 19 (*particular*). Nov. 16, 1839.—From Warrington to Liverpool and Manchester junction; distance, 5 miles. Train, three first-class carriages, one mail, one horse-box and two horses, and one chariot on truck; gross load, 55,392 lbs. Engine, Sunbeam: average pressure, 55 lbs.; distance performed in 12·85 minutes; no stoppage. Average velocity, 23·34 miles an hour; highest rate of velocity equal to 34·09 miles an hour, which was attained on the acclivity of 1 in 626. The speed on the acclivity of 1 in 85, near the junction, varied from 30·61 to 20·83 miles an hour.

No. 20 (*general*). November 16, 1839.—From Liverpool and Manchester junction to Warrington; distance, 5 miles. Train, two first-class and two second-class coaches, one carriage on truck, one horse-box and two horses, and one luggage-van; gross load, 60,488 lbs. Engine, Torch: time occupied 14·63 minutes, giving an average speed of 21·38 miles per hour.

No. 21 (*general*). November 16, 1839.—From Warrington to Birmingham; distance, 77·50 miles. Train, two first-class and four second-class coaches, one carriage on truck, one horse-box and two horses, one luggage-van, and one truck with merchandise; gross load, 79,328 lbs. Engine, Torch: distance performed in 242·10 minutes; twenty stoppages, occupying together 47·27 minutes, giving an average of 2·36 minutes for each stoppage. Time in motion, 194·83 minutes; average speed throughout equal to 23·86 miles per hour.

No. 22 (*general*). November 18, 1839.—From Birmingham to Warrington, 77·50 miles. Train, five first-class coaches, one mail, and post-office; gross load, 83,044 lbs. Engine, Basilisk: average pressure of steam, 56 lbs.; time occupied 188 minutes; five stoppages, occupying together 16·59 minutes. Time in motion, 171·41 minutes; average velocity throughout 27·12 miles an hour.

No. 23 (*particular*). November 19, 1839.—From Liverpool and Manchester junction to Warrington; distance, 5 miles. Train, four first-class coaches, one mail, one carriage on truck, one truck with merchandise; gross load, 63,144 lbs. Engine, Lynx: average pressure of steam, 55 lbs. Time in motion, 10·20 minutes; no stoppages. Average speed, 29·41 miles an hour; highest rate of speed, 35·71 miles, which was attained on the declivity of 1 in 660; on the succeeding declivity of 1 in 85; the speed at the top was at the rate of 25·86 miles, and at the bottom 35·71 miles per hour.

No. 24 (*particular*). Nov. 19, 1839.—From Warrington to Liverpool and Manchester junction; distance, 5 miles. Train, one first-class, four second-class, and one third-class carriage, and one horse-box (No. 29) and two horses; gross load, 58,360 lbs. Time in motion, 10·36 minutes; average rate of speed, 28·95 miles per hour; highest velocity, 41·60 miles an hour, which was attained on the acclivity at the junction of 1 in 660: the speed, on the ascent of 1 in 85, varied from 32·60 miles at the bottom to 26·78 miles per hour at the top.

VI. *Great Western Railway*.—Entirely first-class gradients on portions of line on which experiments were made; chiefly ascending planes from London; locomotive engines, class A.

Experiment, No. 1 (general). June 4, 1838.*—From Paddington to Maidenhead, chiefly ascending; distance, 22·50 miles. Train consisted of two first-class, two closed second-class, and two open second-class coaches, and one posting carriage; average gross load, 80,078 lbs. Engine, *Æolus*: distance performed in 102·75 minutes; two stoppages, occupying together 76 minutes. The principal part of the time occupied by the stoppages was at West Drayton, in consequence of a leakage in one of the tubes, whereby the fire was extinguished, so that the train was delayed till the arrival of the following train from London. Time in motion, 86·75 minutes; average speed, 15·56 miles per hour. From Drayton the engine leading the following train had both trains to move forward.

No. 2 (*general*). 4th June, 1838.—From Maidenhead to Paddington, chiefly descending; distance, 22·50 miles. Train same as of No. 1; the posting-carriage, in consequence of one of the wheels firing, was taken off at Slough. Average gross load, 74,678 lbs.; time occupied 62 minutes; three stoppages, occupying together 7·75 minutes. Time in motion, 54·25 minutes; average speed, 24·88 miles an hour.

No. 3 (*particular*). July 21, 1838.—From Paddington to Maidenhead; distance, 22·50 miles. Train, three first-class, two second-class open, and one second-class closed, and two stages on trucks; average gross load, 96·194 lbs. Engine, *Æolus*: distance performed in 150 minutes; four stoppages, occupying together 34·65 minutes. Time in motion, 115·25 minutes; average speed, 11·71 miles per hour. Leaving Paddington, the first mile was performed at the rate of 6·49 miles per hour, and the second mile at the rate of 6·16 miles per hour. About the 2½ mile standard the train was suddenly stopped, and remained *in statu quo* for 21·75 minutes. In the meantime, *Æolus* moved slowly away to recover his strength; and having sufficiently exercised himself, returned, after a lapse of 21·75 minutes, to lead the train forward. The next half mile was performed at the rate of 4·90 miles per hour; the fourth mile at 5·71 miles; the fifth at 8·57; the sixth at 10·43; the seventh at 15 miles; and on the level plane, at the tenth mile, the speed had reached 20 miles an hour. On descending the plane of 1 in 1715, the speed for 1½ miles was about 24 miles an hour, which was the highest during the trip. Having taken in water at West Drayton, the train proceeded at the rate of 12 miles an hour, and rose to 21·81 miles at the 18th mile standard. Leaving Slough station, the speed was nearly uniformly at the rate of 20 miles an hour till within ¼ of a mile of Maidenhead.†

No. 4 (*particular*). July 21, 1838.—From Maidenhead to Paddington; distance, 22·50 miles. Train, one large second-class carriage, one small second-class closed, one small second-class open; two

* First opened for traffic.

† The gradual increase of speed which took place from the opening of the line, on the 4th June, 1838, to 7th March, 1840 (experiments Nos. 24 and 25), is distinctly shewn by the results of these experiments.

first-class carriages, and two stages on trucks; gross load, 80·266 lbs. Engine, *Æolus*; Lion assisting as far as West Drayton. Time occupied, 65·50 minutes; two stoppages, occupying together 6·50 minutes. Time in motion, 59 minutes; average velocity, at the rate of 22·88 miles an hour; highest velocity, 30 miles, on planes descending 1 in 1320, 1 in 1980, and 1 in 1204. On a level, the speed was equal to 26·66 miles an hour. The velocity was reduced at the mile about each stopping-place to an average rate of 15·50 miles per hour.

No. 5 (*particular*). Nov. 6, 1838.—From Paddington to Maidenhead; distance, 22·50 miles. Train, one first-class, one second-class closed, and one second-class open carriage; gross load, 44,440 lbs. Engine, *Æolus*. Time occupied, 45·50 minutes; two stoppages, occupying together 2·50 minutes. Time in motion, 43 minutes; average speed, 31·39 miles an hour; the highest rate of speed was 48 miles, which was attained on the declivities of 1 in 1715 and 1 in 1320, towards Drayton.

No. 6 (*particular*). Nov. 6, 1838.—From Maidenhead to Paddington; distance, 22·50 miles. Train, one second-class closed, one second-class open, one first-class carriage, and two stages on trucks; gross load, 57·524 lbs. Engine, *Venus*: distance performed in 67·75 minutes; two stoppages, occupying together 3·75 minutes. Time in motion, 64 minutes; average velocity, 21·09 miles an hour; the highest velocity was at the rate of 34·28 miles an hour, which was attained on the declivity of 1 in 1204 towards Paddington. On the level plane, about 10 miles from London, the speed was at the rate of 30 miles an hour. About the stoppages (taking the mile) the rate of speed was reduced on an average to about 17 miles an hour.

No. 7 (*particular*). July 20, 1839.—From Paddington to Twyford; distance, 30·75 miles. Train, three first-class, and three second-class carriages, one horse-box and two horses, and two carriages on trucks; gross load, 106,944 lbs. Engine, *Atlas*: distance performed in 90·80 minutes; four stoppages, occupying together 8·47 minutes. Time in motion, 82·33 minutes; average speed, 22·40 miles an hour; highest speed equal to 33·33 miles per hour, which occurred on the planes ascending 1 in 1204 from the 6th to the 7th mile standard, and for the distance between the 20½ mile standard and the 21st mile standard, the acclivity rising at the rate of 1 in 1320. At ¼ of a mile about each stopping-place the speed was reduced to an average rate of 6·87 miles an hour.

No. 8 (*particular*). July 20, 1839.—From Twyford to Paddington; distance, 30·75 miles. Train, three first-class and three second-class carriages, and one horse-box and one horse; gross load, 85·760 lbs. Engines, *Ajax* and *Neptune*. Time in motion, 72 minutes; three stoppages, occupying together 5·71 minutes. Time in motion, 66·29 minutes; average speed throughout, 27·83 miles per hour. The highest rate of speed was equal to 50 miles an hour for ¼ mile on the upper part of the declivity towards Paddington of 1 in 1760. The following rates of speed were attained during the trip: 40 miles an hour for two miles on a plane descending at the rate of 1 in 1320; 46·15 miles an hour for ¼ mile on the same declivity; 40 miles an hour on a level; and 42·85 miles on an acclivity of 1 in 1320 respectively. About the stoppages (for the ¼ of a mile) the average rate of speed was reduced to 8·85 miles an hour.

No. 9 (*particular*). Aug. 8, 1839.—From Paddington to Slough: distance, 18·25 miles; strong head wind. Train, two first-class and three second-class carriages, one carriage on truck, and two horse-boxes with three horses; gross load, 97·706 lbs. Engine, *Lion*: distance performed in 49·06 minutes; one stoppage at West Drayton, occupying ·98 minute. Time in motion, 48·07 minutes; average speed, 22·77 miles an hour; highest rate of speed, 41·66 miles an hour, attained on the declivity of 1 in 1320 towards Slough, for the distance of ¼ of a mile. At the ¼ of a mile about the West Drayton stoppage the speed was reduced to 8·28 miles an hour.

No. 10 (*particular*). Aug. 8, 1839.—From Slough to London: distance, 18·25 miles. Train, two 4-wheel first-class, one 6-wheel first-class, and three second-class carriages, two carriages on trucks, one stage on truck, and four empty trucks; gross load, 133·079 lbs. Engine, *Evening Star*:

distance performed in 42·95 minutes; one stoppage, occupying ·70 minute. Time in motion, 42·25 minutes; average speed, 25·91 miles an hour; highest speed, 42·85 miles, attained on the declivity towards Paddington of 1 in 1204.

No. 11 (*particular*). August 9, 1839. — From Paddington to Slough; distance, 18·25 miles. Train, three first-class and three second-class carriages, and two carriages on truck; gross load, 95,512 lbs. Engine, Evening Star: distance performed in 41·70 minutes; one stoppage at West Drayton, occupying 2·34 minutes. Average speed equal to 27·82 miles an hour; highest speed, 44·11 miles an hour, on declivity of 1 in 1715, at 12 miles from London. For nearly 12 miles of the distance collectively the speeds varied from 30 miles to 44·11 miles an hour.

No. 12 (*particular*). August 9, 1839. — From Slough towards Paddington; distance, 16·50 miles. Train, three first-class, three second-class carriages, and two stages and one carriage on trucks; gross load, 99,354 lbs. Engine, Atlas: distance performed in 33·09 minutes; no stoppage. Average speed, 29·91 miles per hour; highest rate of speed, 42·85 miles an hour on declivity of 1 in 1715. A speed of 37·50 miles an hour was repeatedly attained during the trip.

No. 13 (*particular*). August 12, 1839. — From Paddington to West Drayton: distance, 13 miles. Train, one first-class (4-wheel) and two second-class (4-wheel) carriages, and 4-wheel chaise on truck; gross load, 39,698 lbs. Engine, Vulcan: distance performed in 30·40 minutes; three stoppages, occupying together 2·86 minutes. Time in motion, 27·54 minutes; average speed throughout, 28·32 miles an hour; highest rate of speed, 50 miles an hour, on the declivity towards West Drayton of 1 in 1715. At the $\frac{1}{4}$ -mile about each stopping-place the speed was reduced to an average rate of 10·50 miles an hour.

No. 14 (*particular*). August 12, 1839. — From West Drayton to Paddington; distance, 13 miles. Same train as last, excepting chaise on truck; gross load, 31,356 lbs. Engine, Vulcan: whole time occupied, 40·60 minutes; four stoppages, occupying together 3·63 minutes. Time in motion, 36·97 minutes; average speed, 21·09 miles an hour; highest rate of speed, 50 miles an hour, on declivity of 1 in 1760 towards Paddington. About the stopping-places the speed was reduced on an average to 7·35 miles an hour.

No. 15 (*particular*). August 14, 1839. — From Paddington to Slough; distance, 18·25 miles. Train, one first-class (6-wheels), two first-class (4-wheels), and three second-class carriages, one carriage on truck, one horse-box and two horses; gross load, 107,698 lbs. Engine, Morning Star: distance performed in 47·75 minutes; one stoppage, occupying 2 minutes. Time in motion, 45·75 minutes; average rate of speed, 23·93 miles per hour; the highest velocity attained was equal to 39·47 miles per hour, on the level plane beyond West Drayton. For the $\frac{1}{4}$ -mile about the West Drayton station the speed was reduced to 10 miles an hour.

No. 16 (*particular*). August 14, 1839. — From Slough to London; distance, 18·25 miles. Train, one 6-wheel first-class, two 4-wheel first-class, and three 6-wheel second-class carriages, and two carriages and two stages on trucks; average gross load, 104,464 lbs. Engine, Atlas: distance performed in 41·66 minutes; no stoppage. Average speed throughout equal to 26·28 miles an hour; highest rate of speed, 37·50 miles an hour on an acclivity of 1 in 1320, and again on a declivity of 1 in 1204.

No. 17 (*particular*). December 13, 1839. — From Paddington to Twyford; distance, 30·75 miles; rails wet; fine weather. Train, one first-class (4-wheels), one first-class (6-wheels), two second-class (6-wheels) carriages, three stages on trucks (slipped off at Maidenhead), and one horse-box with one horse; average gross load, 95,022 lbs. Engine, Evening Star: average pressure of steam, 52 lbs.; time occupied, 69·65 minutes; two stoppages, occupying together 4·12 minutes. Time in motion, 65·53 minutes; average speed, 28·15 miles per hour; highest rate of speed equal to 44·11 miles an hour for a distance of $\frac{1}{4}$ of a mile on the acclivity towards Twyford of 1 in 1320. About the two stoppages the average rate of speed was reduced to 5·58 miles an hour.

No. 18 (*particular*). December 13, 1839. — From Twyford to Paddington; distance, 30·75 miles; rain fell at 19 miles from London. Train, one 6-wheel first-class, one 4-wheel first-class, two 6-wheel second-class carriages, one luggage-truck, two empty 4-wheel trucks; gross load, 90,450 lbs. Engine, Evening Star: average pressure of steam, 52 lbs.; whole time occupied, 73·10 minutes; four stoppages, occupying together 6·88 minutes. Time in motion, 66·22 minutes; average speed, 27·86 miles per hour; highest speed, 48·38 miles an hour, on the declivity near Twyford of 1 in 1320. The rates of speed attained above 35 miles an hour extended over a collective length of 11 miles. The speed for the $\frac{1}{4}$ -mile distance about each stopping-place was reduced on an average to 8·27 miles per hour.

No. 19 (*particular*). Dec. 13, 1839. — From Paddington to West Drayton; distance, 13 miles; alight breeze. Train, one 4-wheel first-class, and two 4-wheel second-class carriages; gross load, 31,356 lbs. Engine, Bacchus: average pressure of steam, 50 lbs.; whole time occupied, 31·90 minutes; three stoppages, occupying together 5·07 minutes. Time in motion, 26·83 minutes; average rate of speed, 29·07 miles per hour; highest rate of speed, 44·11 miles per hour, which occurred on the acclivity of 1 in 1204, $4\frac{1}{2}$ miles from London. The speed about the stoppages, which averaged each 1·69 minutes, was as high as 23·38 miles an hour on an average.

No. 20 (*particular*). December 13, 1839. — From West Drayton to Twyford; distance, 17·50 miles. Train, two 6-wheel second-class, one 4-wheel first-class, one 6-wheel first-class, one carriage on truck, one laden truck; gross load, 76,482 lbs.; distance performed in 43·19 minutes; two stoppages, occupying together 5·65 minutes. Time in motion, 37·54 minutes; average speed, 27·97 miles per hour; highest rate of speed, 50 miles an hour on the Slough acclivity of 1 in 2640. The rates of speed above 35 miles an hour were attained on a collective length of one-fourth of the whole distance.

No. 21 (*particular*). December 13, 1839. — From Twyford to Paddington; distance, 30·75 miles. Train, two 6-wheel second-class, two 4-wheel first-class, one 6-wheel first-class, one stage on truck; average gross load, 78,154 lbs. Engine, Planet: average pressure, 55 lbs.; whole distance performed in 82·50 minutes; three stoppages, occupying together 10·22 minutes. Time in motion, 72·28 minutes; average speed throughout, 25·52 miles per hour; highest speed, 35·71 miles per hour, which was attained on the Twyford plane, descending at the rate of 1 in 1320.

No. 22 (*particular*). January 9, 1840. — From Paddington to West Drayton; distance, 13 miles. Train, one first-class (four wheels), two second-class (four wheels); average gross load, 32,256 lbs. Engine, Bacchus: average pressure of steam, 55 lbs.; whole distance performed in 32·45 minutes; three stoppages, occupying together 2·41 minutes. Time in motion, 30·04 minutes; average speed throughout, 25·96 miles an hour; highest rate of speed equal to 50 miles an hour, attained on the plane descending towards West Drayton at the rate of 1 in 1715. The rates of speed above 35 miles an hour were extended over a collective length of 5 miles. The speed at the $\frac{1}{4}$ -mile about each stoppage was reduced to the average rate of 6·82 miles per hour.

No. 23 (*particular*). January 9, 1840. — From West Drayton to Paddington; distance, 13 miles. Train, one first-class (four wheels), and two second-class carriages (four wheels); average gross load, 33,516 lbs. Engine, Bacchus: average pressure of steam, 55 lbs.; distance performed in 31·80 minutes; two stoppages, occupying together 1·93 minutes. Time in motion, 29·87 minutes; average speed throughout, 26·11 miles per hour; highest velocity, 50 miles an hour, on the level plane (10 miles from Paddington) for a $\frac{1}{4}$ of a mile; and again on the planes descending at the respective rates of 1 in 1204 and 1 in 1760, approaching the London terminus, on the former for a $\frac{1}{4}$ of a mile, and on the latter for $\frac{1}{2}$ a mile respectively. For a collective length of seven miles the rates of speed attained were above 35 miles an hour. The speed at the $\frac{1}{4}$ of a mile about each stoppage was reduced, on an average, to the rate of 10·52 miles an hour.

No. 24 (*particular*). March 7, 1840.—From Paddington to Twyford; distance, 30·75 miles. Train, two second-class (six wheels) carriages, one first-class (six wheels), and one first-class four-wheel carriage, and one four-wheel chaise on truck; gross load, 69,426 lbs. Engine, Eagle: distance performed in 65·02 minutes; three stoppages, occupying together 4·98 minutes. Time in motion, 60·02 minutes; average speed throughout equal to 30·73 miles an hour; highest rate of speed, 45·45 miles an hour, attained on the Twyford acclivity of 1 in 1320. On the same acclivity this speed was followed by that of 44·11 miles an hour for $\frac{1}{4}$ of a mile; and the collective length traversed with speeds ranging from 35 miles an hour upwards amounted to more than half of the whole distance. The speed was reduced to an average rate at the $\frac{1}{4}$ -mile about each stopping-place of 7·96 miles per hour.

No. 25 (*particular*). March 7, 1840.—From Twyford to London; distance, 30·75 miles. As this experiment exhibits the highest rates of velocity taken throughout, we have shewn the results by a diagram in Plate 15. Train, two second-class (six wheels) carriages, one first-class (six wheels), and one first-class (four wheels) carriage, and one luggage-truck; average gross load, 67,240 lbs. Engine, North Star: distance performed in 61·90 minutes; three stoppages, occupying together 3·98 minutes. Time in motion, 57·92 minutes; average speed throughout, 31·85 miles an hour: for the general performance of the engine, see the diagram above referred to. The speed about the stoppages (taking the $\frac{1}{4}$ -mile as before) averaged 8·16 miles per hour.

VII. *Leeds and Selby Railway*.—Second-class gradients; locomotive engines, class E 1; ascending from Leeds for five miles to summit-level, thence descending to Selby. The trains made up generally of Leeds carriages and York carriages.

Experiment, No. 1 (*particular*). August 3, 1839.—From Leeds towards Selby; distance, 13 miles. Train, two first-class, two second-class, and one third-class carriages; time occupied, 45·17 minutes; three stoppages, occupying together 4·40 minutes. Time in motion, 40·77 minutes; average speed at the rate of 19·13 miles an hour; highest speed, 37·50 miles an hour, on the declivity of 1 in 150 (eight miles from Leeds). On making the descent of this incline, the speed at the top was at the rate of 25 miles an hour, and rose to 37·50 in $\frac{1}{4}$ of a mile; then, as it approached the Micklefield station, the brakes being applied, it fell to 22·38 miles an hour, and at the $\frac{1}{4}$ -mile about the stoppage to 8·92 miles an hour. Leaving this station, it rose to 13·39 miles, 21·42 miles, and 33·33 miles an hour respectively; and the descent of the following declivity of 1 in 137 was commenced with a speed of 30 miles an hour, which rose to 35·71 miles before reaching Milford station. About this stoppage it was reduced to an average speed of 13 miles an hour, and afterwards rose to 20·54 miles an hour.

No. 2 (*particular*). August 3, 1839.—From York junction to Leeds; distance, 13·50 miles. Train, three first-class, six second and one third-class carriages, and one luggage-van; gross load, 75,120 lbs. Engine, Hawke: average pressure of steam, 50 lbs.; time occupied, 45·35 minutes; two stoppages, occupying together 1·95 minutes. Time in motion, 43·40 minutes; average speed, 18·66 miles an hour; highest speed, 37·50 miles, on the declivity towards Leeds of 1 in 160. On ascending the plane of 1 in 137, the speed, which at the bottom was at the rate of 17·14 miles an hour, fell in one mile to 8·57 miles an hour, but rose again to 15 and 16·66 miles an hour respectively. On the succeeding acclivity of 1 in 150, the speed ranged from 15·46 to 23·07 miles an hour, except for the $\frac{1}{4}$ -mile about the Micklefield station, where it fell to 15 miles an hour. On the summit-level the speed varied from 20 to 25 miles an hour. Descending the incline of 1 in 168, the speed varied from 25 to 31·91 miles an hour respectively; and on the succeeding declivity of 1 in 160 it ranged from 23·07 to 37·50 miles an hour, which last rate of speed was at the top of the plane.

No. 3 (*particular*). October 26, 1839.—From York junction to Leeds; distance, 13·50 miles.

Train, three first-class carriages, two second-class, and one third-class carriage, and four laden trucks; average gross load, 90,780 lbs. Engine, Dart; assisted by the Hawke engine up the incline of 1 in 137, and along the summit-level: time occupied, 49.02 minutes; three stoppages, occupying together 3 minutes. Time in motion, 46.02 minutes; average speed, 17.60 miles an hour; highest rate of speed, 37.50 miles, for one mile altogether, on the declivity of 1 in 160 towards Leeds. The average speed on the acclivity of 1 in 137 was 15 miles an hour; and on that of 1 in 150, 17 miles an hour.

No. 4 (*general*). October 26, 1839.—From Leeds to York junction; distance, 13.50 miles. Train, three first-class, three second-class, and one third-class carriage; gross load, 58,456 lbs.; distance performed in 44.70 minutes; three stoppages, occupying together 4.38 minutes. Time in motion, 40.32 minutes; average speed, 20 miles an hour.

No. 5 (*particular*). October 27, 1839.—From York junction to Selby; distance, 6.50 miles. Train, two first and four second-class carriages; gross load, 47,424 lbs. Engine, Express: average pressure of steam, 50 lbs.; distance performed in 18.60 minutes; one stoppage, occupying .98 minute. Time in motion, 17.62 minutes; average velocity, 22.13 miles an hour; highest velocity, 30 miles an hour, which was attained three times on the declivity of 1 in 3785.

No. 6 (*particular*). Oct. 29, 1839.—From Selby to York junction; distance, 6.25 miles. Train, three second-class, one first-class, and one mixed carriage, and one truck with merchandise; gross load, 43,370 lbs. Engine, Lord Hood: average pressure of steam, 50 lbs.; distance performed in 16.16 minutes; no stoppage. Average speed throughout, 23.20 miles per hour; highest speed at the rate of 30 miles an hour.

No. 7 (*general*). Oct. 29, 1839.—From York junction to Leeds; distance, 13.50 miles; rails wet. Train, three first-class, two second-class, and one third-class carriage. Engine, Express: average pressure of steam, 50 lbs.; whole time occupied, 40.75 minutes; two stoppages, occupying together .62 minute. Time in motion, 40.13 minutes; average speed, 20.18 miles an hour.

No. 8 (*particular*). Oct. 31, 1839.—From Leeds to Milford; distance, 12 miles. Train, two first-class, four second-class, and one third-class carriage, and two trucks; average gross load, 59,128 lbs. Engine, Dart: average pressure of steam, 50 lbs.; distance performed in 31.55 minutes; two stoppages, occupying together one minute. Time in motion, 30.55 minutes: average speed throughout, 23.56 miles per hour; highest rate of speed, 37.50 miles, on the top of the declivity of 1 in 137. By application of the brakes, it fell to 17.44 miles an hour, but rose again to 35.71 miles between $8\frac{1}{4}$ and $8\frac{1}{2}$ miles from Selby. On the level plane the speed averaged about 25 miles an hour; ascending 1 in 160, 22 miles, and 1 in 168 (the succeeding acclivity), about 23 miles an hour. About the stoppages the speed was reduced to an average rate of 13 miles an hour.

No. 9 (*particular*). Oct. 31, 1839.—From Milford to Leeds; distance, 12 miles. Train, two first-class, three second-class carriages, and one third-class carriage, two horse-boxes and two horses, and two trucks with merchandise; average gross load, 73,360 lbs. Engine, Swallow: average pressure of steam, 45 lbs.; distance performed in 32.82 minutes; two stoppages, occupying together 2.04 minutes. Time in motion, 30.78 minutes; average velocity throughout, 23.39 miles per hour; highest rate of velocity, 38.46 miles an hour, on the declivity of 1 in 160 towards Leeds. The speed on the level plane at summit averaged about 25 miles an hour; on the acclivity of 1 in 137 it rose from 17.85 miles ($8\frac{1}{4}$ miles from Selby) up to 28.30 miles an hour ($9\frac{1}{4}$ miles from Selby); on the succeeding acclivity of 1 in 150 the speed averaged 22 miles an hour. At the $\frac{1}{4}$ -mile about each of the two stoppages the speed was reduced on an average to the rate of 10 miles an hour.

No. 10 (*particular*). Oct. 31, 1839.—From Leeds to York junction; distance, 13.50 miles. Train, one first, one second, and one third-class carriage, and one truck with merchandise; gross load, 37,436 lbs. Engine, Express: average pressure of steam, 50 lbs.; distance performed in 31.38 minutes;

no stoppage. Average speed, 25·81 miles an hour; the highest rate of speed was equal to 35·71 miles an hour, and was attained on the summit-level. On the acclivity of 1 in 160, the speed, which at the bottom was at the rate of 17·24 miles, rose in $1\frac{1}{4}$ mile to 33·33 miles an hour, and at the top of the plane it was equal to 30 miles an hour. On the declivities of 1 in 150, and 1 in 137, the speed averaged throughout about 30 miles an hour.

No. 11 (*particular*). Oct. 31, 1839.—From York junction towards Selby; distance, 6 miles; strong head-wind. Train, three laden coal-wagons, three empty trucks, and five wagon-loads of broken stone; gross load, 97,664 lbs. Engine, Express: average pressure of steam, 50 lbs.; distance performed in 20·10 minutes; no stoppage. Average speed, 17·91 miles; highest speed equal to 26·31 miles per hour, which was attained at bottom of the declivity of 1 in 3785.

No. 12 (*particular*). Oct. 31, 1839.—From Selby to Leeds; distance, 20 miles. Train, one first-class and three second-class carriages, four trucks laden with sheep, and truck laden with stone; gross load, 59,168 lbs. Engine, Dart: average pressure of steam, 50 lbs.; engine Express assisted up inclines of 1 in 137 and 1 in 150; distance performed in 57·65 minutes; four stoppages, occupying together 6·95 minutes. Time in motion, 50·70 minutes; average velocity, 23·66 miles an hour; highest velocity, 44·11 miles an hour, which was attained on the declivity towards Leeds of 1 in 160. The remainder of this plane, and parts of the contiguous declivities of 1 in 168 and 1 in 160, were descended at the rate of 41·66 miles per hour. The acclivity of 1 in 137 was ascended at speeds varying from 15 to 23 miles an hour; and on the adjoining acclivity of 1 in 150 the speeds varied from 16 to 24 miles an hour: on the summit-level plane the speed averaged about 25 miles an hour. At the $\frac{1}{4}$ -mile about each stoppage the average speed was reduced to 10·44 miles an hour.

No. 13 (*general*). Oct. 31, 1839.—From Leeds to York junction; distance, 13,50 miles. Train, three first-class, three second-class, and one third-class carriage; gross load, 58,456 lbs. Engine, Dart: average pressure of steam, 50 lbs.; distance performed in 40·30 minutes; no stoppage. Average speed, 20·09 miles per hour.

VIII. *Liverpool and Manchester Railway*.—First and third-class gradients; locomotive engines, class E.

Experiment, No. 1 (*particular*). Jan. 16, 1839.—From Manchester to Warrington junction; distance, 15·75 miles. Train, three first-class carriages and one luggage-van; gross load, 42,040 lbs. Engine, Zaniel (belonging to Grand Junction Railway Company): distance performed in 34·10 minutes; no stoppage. Average speed equal to 27·71 miles per hour; highest rate of speed, 32·08 miles an hour, on declivity of 1 in 4257.

No. 2 (*particular*). Aug. 1, 1839.—From Manchester to Parkside; distance, 14 miles. Train, seven first-class and one second-class carriage; gross load, 82,579 lbs. Engine, *Ætna*: distance performed in 35·75 minutes; one stoppage, occupying ·60 minute. Time in motion, 35·15 minutes; average speed, 23·89 miles per hour; highest rate of speed, 37·50 miles an hour on the plane descending at the rate of 1 in 1300. For the $\frac{1}{4}$ -mile about the stoppage at Flow Moss station the speed was reduced to 9·80 miles an hour.

No. 3 (*general*). Aug. 3, 1839.—From Manchester to Warrington junction. Train, four first-class carriages, one mail, post-office added at Parkside; average gross load, 50,918 lbs.; distance performed in 36·60 minutes; one stoppage, occupying 6·25 minutes. Time in motion, 30·35 minutes; average speed 29·75 miles an hour.

No. 4 (*particular*). Aug. 30, 1839.—From Warrington junction to Edge Hill; distance, 13 miles. Train, four first-class carriages, one mail, two carriages on trucks, one horse-box, and two horses; gross

load, 70,630 lbs. Engine, Lynx (Grand Junction Company): distance performed in 30 minutes; no stoppage. Average speed, 26 miles an hour; the highest rate of speed, 37.50 miles an hour, was attained on the Rainhill level. On making the ascent of the Sutton incline of 1 in 89, the speed, which on entering it from the acclivity of 1 in 2762 was at the rate of 30 miles an hour, fell to 16 miles an hour in one mile, and rose again to 24.19 miles an hour on entering upon the Rainhill level. On the Whiston declivity of 1 in 96 the rates of speed were 30, 21, 42, and 25 miles an hour respectively, the highest rate being at top.

No. 5 (*general*). Nov. 9, 1839.—From Manchester to Liverpool; distance, 30.75 miles. Train, six first-class and three second-class carriages; gross load, 87,657 lbs. Engine, Milo: distance performed in 87.20 minutes; three stoppages, occupying together 3.70 minutes. Time in motion, 83.50 minutes; average rate of speed throughout, 22.09 miles per hour.

No. 6 (*particular*). Nov. 11, 1839.—From Liverpool to Newton, 14.25 miles. Train, four first-class and one second-class carriage; gross load, 50,563 lbs.; distance performed in 29.48 minutes; one stoppage, occupying 1.50 minutes. Time in motion, 27.98 minutes; average velocity, 30.55 miles an hour; highest velocity, 50 miles an hour, in descending plane inclining at the rate of 2762. In ascending the Whiston incline, the speed, which at the bottom was equal to 35.71 miles an hour, fell gradually to 23.80 miles an hour at top; on the Rainhill level the speed varied from 29.41 to 32.60 miles an hour. The rates of speed in descending the Sutton incline rose from 30 miles an hour at the top to 35.71 miles an hour at the bottom (see Diagram, Plate 15).

No. 7 (*particular*). Nov. 11, 1839.—From Newton to Liverpool; distance, 14.25 miles. Train, six first-class carriages, one mail, and one second-class carriage; gross load, 79,057 lbs. Engine, Rokeby; Buffalo assisted up Sutton incline: distance performed in 41.30 minutes; no stoppage. Average speed equal to 20.70 miles an hour; highest rate of speed, 46.87 miles an hour, which was on entering the Whiston declivity of 1 in 96. On the Sutton incline the rates of speed varied from 14.70 miles at the bottom to 22.05 miles an hour at the top.

No. 8 (*particular*). November 11, 1839.—From Liverpool to Newton; distance, 14.25 miles. Train, five first-class carriages and one mail; gross load, 60,510 lbs. Engine, Arrow: distance performed in 30.10 minutes; no stoppage. Average speed, 28.40 miles an hour; highest speed, 34.88 miles an hour, which was attained on the Broad Green declivity of 1 in 1094, and again on the St. Helen's declivity of 1 in 2762. In ascending the Whiston incline the speed at the bottom was equal to 30.61 miles an hour, and fell gradually to 20.27 miles at top; on the Rainhill level the speed averaged 24 miles an hour. On descending the Sutton declivity, the speed, which at top was at the rate of 27.77 miles per hour in the first $\frac{1}{4}$ -mile, fell to 25.66, and at the bottom it was equal to 31.91 miles an hour.

No. 9 (*particular*). November 11, 1839.—From Newton towards Liverpool; distance, 13.75 miles; rails wet. Train, two first-class and four second-class carriages; gross load, 52,484 lbs. Engine, Vesuvius: distance performed in 48.40 minutes; seven stoppages, occupying together 6.74 minutes. Time in motion, 41.66 minutes; average speed, 19.80 miles an hour; highest rate of speed, 33.33 miles, twice attained on the St. Helen's acclivity of 1 in 1094. Ascending the Sutton acclivity, the speed varied from 21.42 miles an hour to 25 miles, and afterwards declined to 9.37 miles, but rose at top to 29.41 miles an hour; on the Rainhill level the average speed, excepting about the stoppage, was equal to 25 miles an hour; on the Whiston declivity the speed varied (gradually increasing) from 18.75 miles at top to 27.77 miles an hour at bottom. The speed at the $\frac{1}{4}$ -mile about each stoppage was reduced on an average to 12.63 miles per hour.

No. 10 (*particular*). November 11, 1839.—From Liverpool to Newton; distance, 14.25 miles. Train, one mail, four first-class carriages, one empty truck; gross load, 53,198 lbs. Engine, Roderic: distance performed in 32.10 minutes; one stoppage, occupying 1.74 minutes. Time in motion, 30.36

minutes; average speed, 28·16 miles an hour; highest rate of speed, 44·11 miles an hour, attained on the Rainhill level. The speed of 25 miles an hour was maintained throughout the ascent of the Whiston incline. On descending Sutton, the speed commenced at 30·61 miles, and terminated at 34·88 miles an hour, the brakes being applied as usual.

No. 11 (*particular*). November 11, 1839. — From Newton to Liverpool; distance, 14·25 miles. Train, two first-class and five second-class carriages, two horse-boxes and two horses, and one carriage on truck; gross load, 78,975 lbs. Engine, Arrow; assisted by another engine up Sutton incline: distance performed in 52 minutes; seven stoppages, occupying together 8·99 minutes. Time in motion, 43·01 minutes; average speed throughout, 19·87 miles an hour; the highest rate of speed was equal to 40·54 miles an hour, and was attained on the Broad Green declivity of 1 in 1094. On ascending the Sutton acclivity, the speed at bottom was equal to 17·64 miles an hour, and rose to 22·05 miles at top. On the Rainhill level the speed was on an average equal to 22 miles an hour. On the descent of the Whiston incline, the speed at top was equal to 25 miles, and at bottom to 28·84 miles an hour (furnace-door open). At the $\frac{1}{4}$ -mile about each stoppage the average speed was reduced to 12·56 miles an hour.

No. 12 (*general*). November 16, 1839. — From Edgehill to Warrington junction; distance, 13 miles. Train, one first-class carriage, one mail; gross load, 15,302 lbs. Engine, Oberon (Grand Junction Company): distance performed in 26·80 minutes; no stoppage. Average speed, 29·10 miles per hour.

No. 13 (*particular*). November 16, 1839. — From Warrington junction to Liverpool; distance, 13 miles. Train, three first-class carriages, one mail, one chariot on truck, one horse-box and one horse; gross load, 54,882 lbs. Engine, Sunbeam (Grand Junction Company): distance performed in 32·26 minutes; one stoppage, occupying 1·15 minutes. Time in motion, 31·11 minutes; average speed, 25·07 miles an hour; highest rate of speed, 37·50 miles, attained at bottom of Whiston declivity. The speeds on the Sutton acclivity varied from 17·64 at bottom to 16·66 miles in $\frac{1}{4}$ of a mile, and rose again to 27·77 miles at top. On the Rainhill level the speed averaged 29 miles an hour. On the Whiston declivity (steam off) the speed varied from 15·95 miles at top to 37·50 (steam half on) at bottom, keeping, however, at the uniform speed of 31·25 miles an hour for $\frac{1}{4}$ of a mile.

No. 14 (*particular*). November 16, 1839. — From Edgehill to Warrington junction; distance, 13 miles. Train, two first-class and two second-class carriages, one carriage on truck, one horse-box and one horse, and one luggage-van; average gross load, 58,154 lbs. Engine, Torch (Grand Junction Company): distance performed in 34·40 minutes; five stoppages, occupying together 2·47 minutes. Time in motion, 31·93 minutes; average speed, 24·42 miles an hour; highest rate of speed, 46·87 miles, attained at bottom of Sutton declivity. The speed at bottom of Whiston acclivity was equal to 23·80 miles, and fell towards the top to 8·92 miles per hour. On the Rainhill level, in consequence of two stoppages, the speed was reduced to about 13 miles an hour. The speeds on descending Sutton varied from 28·57 at top (steam off, brake on) to 46·87 at bottom. At the $\frac{1}{4}$ -mile about each stoppage the average speed was reduced to 9 miles an hour.

No. 15 (*particular*). November 19, 1839. — From Liverpool to Warrington junction; distance, 13 miles. Train, four first-class carriages, one mail, one carriage on truck, one truck with goods; gross load, 41,374 lbs. Engine, Lynx: average pressure, 55 lbs.; distance performed in 24·92 minutes; no stoppage. Average speed throughout, 31·30 miles an hour; highest rate of speed, 46·87 miles, attained on the Rainhill level for a quarter of a mile. The speed on the remaining portion of this level averaged 30 miles an hour. On the Whiston acclivity the speed commenced at 30 miles, and left off at 23·43 miles an hour. On the Sutton declivity the speed varied from 34·88 to 40·54 miles an hour.

No. 16 (*particular*). November 19, 1839. — From Warrington junction towards Liverpool; dis-

tance, 12.75 miles; head wind. Train, one first-class, four second-class, and one third-class carriages, one horse-box and one horse; gross load, 56,032 lbs. Engine, Lucifer (Grand Junction Company): average pressure, 55 lbs.; distance performed in 28.65 minutes; no stoppage. Average speed throughout equal to 26.70 miles an hour; the highest rate of speed was 37.50 miles, on ascending the Broad Green incline of 1 in 1094, for a distance of $\frac{1}{4}$ of a mile. Ascending "Sutton," the speed varied from 28.84 miles at bottom (steam full on) to 17.64 miles at top. On Rainhill level (steam half on) the average speed was equal to 28 miles an hour. Descending Whiston (steam off, fire-door open) speed raised from 21.42 to 33.33 miles an hour.

No. 17 (*particular*). November 25, 1839.—From Edgehill to Manchester; distance, 29.25 miles. Train, one first-class and three second-class carriages; average gross load, 34,297 lbs. Engine, Rokeby: average pressure of steam, 56 lbs.; distance performed in 100.88 minutes; sixteen stoppages, occupying together 15.18 minutes. Time in motion, 85.70 minutes; average speed, 20.47 miles an hour. On the Whiston acclivity the speed averaged 16 miles an hour. On the Rainhill level it was, on an average, equal to 25 miles an hour; and on the Sutton declivity the speed at first was equal to 27.27 miles, and at last to 34.88 miles an hour. At the $\frac{1}{4}$ -mile about each stoppage the average speed was reduced to 11.38 miles an hour.

No. 18 (*general*). November 28, 1839.—From Manchester to Edgehill; distance, 29.25 miles. Train, five first-class and one second-class carriages, and one mail; one first and one second-class carriage left at N. Union junction; average gross load, 68.025 lbs. Engine, Comet: distance performed in 70.80 minutes; two stoppages, occupying together 2.33 minutes. Time in motion, 68.47 minutes; average speed throughout equal to 25.63 miles per hour.

No. 19 (*particular*). November 28, 1839.—From Edgehill to Kenyon; distance, 17.25 miles; rails wet. Train, four second-class and two first-class carriages; average gross load, 52,844 lbs. Engine, Sun: average pressure of steam, 60 lbs.; whole time occupied, 54.35 minutes; eight stoppages, occupying together 7.02 minutes. Time in motion, 47.33 minutes; average speed, 21.86 miles an hour; highest speed, 44.11 miles, on the declivity towards Bolton junction of 1 in 894. The Whiston incline was ascended at rates of speed varying from 10.71 to 27.27 miles, and at the top to 18.75 miles an hour.

No. 20 (*particular*). November 26, 1839.—From Kenyon to Edgehill; distance, 17.25 miles. Train, five second-class and three first-class carriages, one horse-box and one horse; gross load, 76,991 lbs. Engine, Arrow, assisted up Sutton by the Mammoth; average pressure of steam (Arrow), 55 lbs.; distance performed in 71.50 minutes; five stoppages, occupying together 10.83 minutes. Time in motion, 60.67 minutes; average speed, 17.05 miles an hour; highest speed, 30.60 miles, attained on the Parkside acclivity of 1 in 894. The ascent of Sutton was effected at rates of speed varying from 13.88 miles to 28.30 miles an hour, which latter speed was at the top. On the Rainhill level the average speed was 30 miles an hour. Descending Whiston the speeds varied from 22 to 30 miles an hour.

No. 21 (*particular*). November 27, 1839.—From Edgehill to Newton; distance, 14.25 miles; head-wind. Train, four first-class, one second-class carriage, one mail, and one horse-box; average gross load, 63,313 lbs. Engine, Roderic: average pressure of steam, 59 lbs.; distance performed in 38.60 minutes; no stoppage. Average speed throughout, 22.15 miles an hour; highest rate of speed, 34.09 miles, attained at bottom of Sutton. The ascent of Whiston was effected by rates of speed varying from 23.07 to 14.15 miles an hour. On the Rainhill level the speed averaged 25 miles an hour. In descending Sutton (brake on towards bottom) the speeds varied from 26 to 34.09 miles an hour.

No. 22 (*particular*). November 27, 1839.—From Newton to top of Sutton; distance, 5.50 miles. Train, ten wagons, partly laden; gross load, 44,800 lbs. Engine, Mastodon: average pressure of steam, 52 $\frac{1}{2}$ lbs.; time occupied, 19.33 minutes; no stoppage. Average speed, 17.07 miles per hour. In

ascending Sutton (steam full on) the speed at bottom was equal to 7·42 miles an hour, increased to 21·12 miles, and at the top fell to 16·85 miles an hour.

No. 23 (*particular*). November 27, 1839.—From top of Sutton to St. Helen's junction; distance, 1·75 miles. Train, two first-class, and four second-class carriages; gross load, 59,999 lbs. Engine, Roderic: average pressure of steam, 58 lbs. The speed in descending Sutton increased from 18·75 miles to 30 miles an hour.

No. 24 (*general*). November 27, 1839.—From St. Helen's junction to Liverpool; distance, 10·25 miles. Train, one first-class and three second-class carriages; gross load, 32,757 lbs. Engine, Roderic: distance performed in 31 minutes; three stoppages, occupying together, 1·82 minutes. Time in motion, 29·18 minutes; average rate of speed throughout, 21·07 miles per hour.

No. 25 (*particular*). November 28, 1839.—From Edgehill to Newton; distance, 14·25 miles. Train, one mail, four first-class and one second-class carriage, and one horse-box and one horse; average gross load, 64,213 lbs.; distance performed in 33·12 minutes; no stoppage. Average velocity, 25·81 miles an hour; highest velocity, 35·71 miles, attained on the Broad Green declivity of 1 in 1094. The Whiston plane was ascended at rates of speed varying from 28·30 to 18·51 miles per hour, decreasing regularly. On the Rainhill level the average speed was equal to 25·50 miles per hour. On the descent of Sutton the rate of speed, which at top was equal to 27·27 miles an hour, was increased to only 29·41 miles an hour at bottom.

No. 26 (*particular*). November 28, 1839.—From Warrington junction to N. Union junction; distance, 1·75 miles. Train, one first-class, three second-class carriages; gross load, 34,297 lbs. Engine, Rokeby: distance performed in 11·12 minutes; two stoppages, occupying together 4·88 minutes. Time in motion, 6·24 minutes; average speed, 16·82 miles an hour; highest speed, 35·71 miles an hour, attained on the Newton declivity of 1 in 894.

No. 27 (*particular*). November 28, 1839.—From North Union junction to Liverpool; distance, 15 miles; rails greasy. Train, two first-class and three second-class carriages; average gross load, 41,909 lbs. Engine, Arrow; Mammoth assisted Arrow up Sutton: distance performed in 49·37 minutes; six stoppages, occupying together 7·72 minutes. Time in motion, 41·65 minutes; average speed throughout, 21·60 miles an hour; highest speed equal to 32·60 miles an hour, ascending the St. Helen's declivity of 1 in 2762. The ascent of Whiston was commenced at a rate of speed at the bottom of 16·12 miles an hour, and terminated at top with a speed equal to 22·72 miles an hour. The average velocity on the Rainhill level was equal to 30 miles an hour. The descent of Sutton was accomplished at speeds varying from 11·62 miles at top to 30 miles an hour at bottom. The speed at the $\frac{1}{4}$ -mile about each stoppage was reduced to an average rate of 12·96 miles per hour.

No. 28 (*particular*). December 2, 1839.—Edgehill to Manchester; distance, 29·25 miles. Train, one first-class and four second-class carriages; average gross load, 41,812 lbs. Engine, Panther: distance performed in 98·40 minutes; twelve stoppages, occupying together 12·13 minutes. Time in motion, 86·27 minutes; average speed throughout, 20·34 miles an hour; highest rate of speed, 40·54 miles an hour, on St. Helen's declivity of 1 in 2762. The rates of speed in ascending the Whiston incline varied from 25·42 miles at bottom to 21·12 miles an hour at top. In consequence of the stoppage at Rainhill station, the speed on this level was not equal to more, on an average, than 22 miles an hour. The Sutton declivity was passed at rates of speed varying from 11·53 miles to 30 miles an hour, increasing regularly from the top downwards.

IX. *London and Birmingham Railway*.—First-class gradients; passenger-engines, class E 1. Line alternates in acclivities and declivities; the maximum of first-class gradients chiefly prevails throughout; as far as Tring summit the line is chiefly ascending (see “Gradients,” in description of this line, page 220).

Experiment, No. 1 (particular). July 20, 1837.—Line opened to the public as far as Boxmoor. From London to Boxmoor; distance, 23·50 miles. Train, three first, three second, and three third-class carriages; gross load, 72,312 lbs.; distance performed in 97·25 minutes; three stoppages, occupying together, 7·16 minutes. Time in motion, 75·75 minutes; average speed, 18·61 miles an hour; highest rate of speed, 26·66 miles, descending incline of 1 in 440, about 16 miles from London. Ascending planes of 1 in 330, the speed was under 22 miles an hour.

No. 2 (particular). July 26, 1837.—London to Harrow; distance, 11·25 miles. Train, four first-class and ten open carriages; gross load, 137,968 lbs.; distance performed in 45·25 minutes; two stoppages, occupying together 5 minutes. Time in motion, 40·25 minutes; average speed throughout equal to 16·79 miles an hour; highest rate of speed, 24 miles an hour, on the level plane beyond Kensal Green.

No. 2 a (particular). July 26, 1839.—From 11-mile standard, near Harrow station, to London; distance, 11 miles. Average gross load of train, 109,168 lbs.; distance performed in 34·50 minutes; one stoppage, occupying 6·50 minutes. Time in motion, 28 minutes; average speed throughout equal to 23·57 miles per hour; highest rate of speed, 30 miles, on the Harrow declivity of 1 in 341, and again on the Kilburn declivity of 1 in 600.

No. 2 b (general). August 25, 1839.—London to 11-mile standard. Average gross load of train, 109,168 lbs.; distance performed in 36 minutes; two stoppages, occupying together 4·25 minutes. Time in motion, 31·75 minutes; average rate of speed equal to 20·78 miles an hour.

No. 3 (general). October 17, 1837.—From London to Tring; distance, 31·75 miles. Train, five first-class, seven second-class carriages; average gross load, 119,176 lbs.; whole distance performed in 107·50 minutes; five stoppages, occupying together 19·50 minutes. Time in motion, 88 minutes; average speed throughout equal to 21·68 miles per hour.

No. 4 (general). May 18, 1838.—From Camden depôt to Denbigh Hall; distance, 46·75 miles. Average gross weight of train, 85,648 lbs.; whole time occupied, 137·50 minutes; six stoppages, occupying together, 23·75 minutes. Time in motion, 113·75 minutes; average speed throughout equal to 24·65 miles an hour.

No. 5 (particular). May 18, 1838.—From Denbigh Hall to London; distance, 47·75 miles. Train, nine first and second-class carriages, six carriages on trucks, one stage on truck, two horse-boxes and four horses; gross load, 149,840 lbs. Two engines: distance performed in 136·50 minutes; three stoppages, occupying together 11·75 minutes. Time in motion, 124·75 minutes; average speed throughout, 22·96 miles an hour; highest rate of speed, 40 miles an hour, on the plane descending from Tring at 1 in 330. The speed at the $\frac{1}{4}$ -mile about each stoppage was reduced to an average rate of 17·56 miles an hour.

No. 6 (particular). January 10, 1839.—From London to near Birmingham station; distance, 112 miles. Train, two first and four second-class carriages and one luggage-van; average gross load, 55,296 lbs.; distance performed in 361·10 minutes; sixteen stoppages, occupying altogether 82·37 minutes. Time in motion, 278·73 minutes; average speed, 26·94 miles per hour; highest rate of speed, 37·50 miles, on the acclivity beyond Brandon of 1 in 330. The average speed at the mile about each stoppage was reduced, on an average, to 16·88 miles an hour.

No. 7 (particular). January 17, 1839.—From Birmingham to London; distance, 112·25 miles.

Train, four first-class carriages, one carriage on truck, and one luggage-van; gross load, 49,328 lbs.; distance performed in 312·10 minutes; ten stoppages, occupying together 62·12 minutes. Time in motion, 249·98 minutes; average speed throughout, 26·94 miles an hour; highest rate of speed, 37·50 miles, on the Harrow declivity of 1 in 341, for two miles; and also on the declivity of 1 in 528 beyond Watford, for one mile. The speed at the mile about each stoppage was reduced to an average rate of 18·91 miles per hour.

No. 8 (*particular*). From London to Birmingham; distance, 112·25 miles. Train, seven first-class carriages, three mails, six carriages on trucks; average gross load, 144,832 lbs. Two engines, as far as Tring, where four of the carriage-trucks were taken of: distance performed in 330·50 minutes; eight stoppages, occupying together 43·60 minutes. Time in motion, 286·90 minutes; average speed equal to 23·47 miles an hour; highest rate of speed, 33·33 miles an hour, descending plane of 1 in 330 (102 miles from London). Ascending the long acclivity towards Tring of 1 in 330, the speed (with two engines) varied from 22·22 to 26·66 miles an hour. On descending the declivity of 1 in 330 beyond Tring, the speeds varied from 25·75 to 32·43 miles an hour. At the mile distance about each stoppage the average speed was reduced to 14·58 miles an hour.

No. 9 (*particular*). June 15, 1839. — From Birmingham to London; distance, 112·25 miles. Train, three first-class, two second-class carriages, one mail, and three trucks; gross load, 68,424 lbs.; distance performed in 313 minutes; nine stoppages, occupying together 38·32 minutes. Time in motion, 274·68 minutes; average speed, 24·48 miles an hour; highest rate of speed, 35·29 miles, attained on the declivity between Blisworth and Weedon of 1 in 412½. On ascending planes of 1 in 330, the speeds varied from 22·72 to 30·30 miles an hour; and in making the descents of similar inclines the rates of speed were from 27·02 to 33·84 miles an hour.

No. 10 (*particular*). July 31, 1839. — From Camden depôt towards Birmingham; distance, 111 miles. Train, three first-class and five second-class carriages, three carriages on trucks, two horse-boxes and four horses; average gross load, 120,088 lbs.; distance performed in 321·34 minutes; ten stoppages, occupying together 46·33 minutes. Time in motion, 275·01 minutes; average speed, 24·21 miles; highest rate of speed, 35·08 miles per hour, attained on the short level plane between Rugby and Coventry. Ascending the incline of 1 in 330 towards Tring, the speeds varied from 18·46 to 22·90 miles per hour. On making the descent of the Tring northern declivity of 1 in 330, the rates of speed varied from 27·27 miles to 32·96 miles an hour. At the ¼-mile about each stoppage the average speed was reduced to 11·10 miles an hour.

No. 11 (*particular*). August 6, 1839. — From Birmingham to Wolverton; distance, 60 miles. Train, three first-class and five second-class coaches, five horse-boxes and three horses, seven trucks, and one truck laden with coke; gross load, 139,276 lbs. Two engines: whole time occupied, 165·90 minutes; nine stoppages, occupying together 29·42 minutes. Time in motion, 136·48 minutes; average speed, 26·37 miles; highest speed, 46·15 miles an hour, ascending the plane of 1 in 848·75 beyond Weedon. On the acclivities of 1 in 330 the speeds varied from 20 to 27·27 miles an hour; and on descending similar declivities the rates of speed fluctuated from 16·66 to 42·85 miles an hour.

No. 12 (*particular*). August 26, 1839. — From Camden depôt to Aylesbury junction; distance, 35·25 miles. Train, seven first-class and seven second-class carriages, branch-coach (No. 104), and horse-box (No. 34) and one horse; gross load, 153,300 lbs. Two engines: distance performed in 108·35 minutes; five stoppages, occupying together 12·85 minutes. Time in motion, 95·50 minutes; average speed throughout, 22·14 miles per hour; highest rate of speed, 33·33 miles, on the declivity beyond Tring of 1 in 330. On the Tring acclivity of 1 in 330 the rates of speed varied from 15·90 miles to 27·77 miles an hour; on descending the Tring declivity of 1 in 330 the speeds fluctuated from 17·96 to 33·33 miles an hour.

No. 13 (*particular*). August 26, 1839.—From Aylesbury junction to Wolverton; distance, 15·75 miles. Train, five first-class, six second-class coaches, two carriages on trucks, one horse-box and one horse, one carriage on truck (taken off at Leighton); average gross load, 128,884 lbs. Engine, No. 23: distance performed in 43 minutes; two stoppages, occupying together 3·30 minutes. Time in motion, 39·70 minutes; average speed, 23·80 miles; highest rate of speed, 37·50 miles an hour, attained on the Bletchley acclivity of 1 in 1100.

No. 14 (*particular*). August 27, 1839.—From Coventry to Birmingham; distance, 18 miles. Train, four first-class coaches, two carriages on trucks, and one empty truck; average gross load, 60,160 lbs. Engine, No. 72: distance performed in 41·10 minutes; one stoppage, occupying 2·60 minutes. Time in motion, 38·50 minutes; average speed, 28·05 miles per hour; highest rate of speed, 42·85 miles an hour, on the declivity of 1 in 330 towards Hampton. On ascending the Coventry acclivity of 1 in 330 the rates of speed varied from 18·64 to 37·50 miles an hour; and on descending the Hampton declivity of 1 in 330 the speed varied from 25 miles to 42·85 miles an hour.

No. 15 (*particular*). September 28, 1839.—From Birmingham to London; distance, 112·25 miles; strong head-wind (from Aylesbury junction to London). Train, three first and three second-class carriages and one truck; average gross load, 61,152 lbs. Engine, No. 34, to Wolverton: whole time occupied, 341·90 minutes; fifteen stoppages, occupying together 57·72 minutes. Time in motion, 284·18 minutes; average speed, 23·69 miles an hour; highest rate of speed, 42·85 miles, ascending the Blisworth acclivity of 1 in 326. In ascending the Tring acclivity of 1 in 330 the speed varied from 15 to 25 miles an hour; and on descending the Tring declivity the rates of speed varied from 20 to 40·95 miles an hour. At the $\frac{1}{4}$ -mile about each stopping-place the average speed was reduced to the rate of 13·10 miles an hour.

No. 16 (*particular*). October 12, 1839.—From London to Hampton; distance, 103 miles; clear morning, head-wind at starting. Train, three first-class, two second-class coaches, four carriages on trucks; one horse-box and one horse; average gross load, 83,924 lbs. Engine, No. 75, from Wolverton: average pressure of steam, 50 lbs.; distance performed in 252·35 minutes; seven stoppages, occupying together 21·62 minutes. Time in motion, 230·73 minutes; average speed, 26·78 miles an hour; highest rate of speed, 50 miles an hour, twice attained on the plane descending towards Hampton of 1 in 330; the other speeds, in making this descent, fluctuated from 29·41 to 40·54 miles an hour. On ascending the Tring acclivity of 1 in 330 the speeds varied from 20·27 to 35·71 miles an hour. At the $\frac{1}{4}$ -mile about each stopping-place the average speed was reduced to 10·44 miles an hour.—See diagram of the speeds exhibited in this experiment in Plate 15.

No. 17 (*particular*). October 13, 1839.—From Hampton to Birmingham; distance, 9·25 miles. Train (B and D), two first-class, two second-class, and two third-class coaches, six trucks partly laden with goods; average gross load, 98,708 lbs. Engine, Trent (six wheels), belonging to Birmingham and Derby Company: average pressure of steam, 55 lbs.; distance performed in 19 minutes; no stoppage. Average speed throughout, 29·21 miles per hour; highest rate of speed, 37·50 miles, on acclivity towards Birmingham of 1 in 660. The rest of the speeds on this incline varied from 31·91 miles to 35·71 miles an hour.

No. 18 (*general*). Nov. 13, 1839.—From Birmingham towards London; distance, 111·13 miles. Train, two first and three second-class coaches, two trucks added at Roade; average gross load, 47,120 lbs. Engine, No. 33 to Wolverton, No. 16 to London: distance performed in 313·12 minutes; sixteen stoppages, occupying altogether 57·35 minutes. Time in motion, 255·77 minutes; average speed throughout, 26·06 miles an hour.

No. 19 (*particular*). November 14, 1839.—From Camden depôt to Birmingham. Train, three first and three second-class coaches, one mail, one carriage on truck, one wagon with three casks; average gross load, 79,032 lbs.; distance performed in 296·25 minutes; nine stoppages, occupying toge-

ther 30·65 minutes. Time in motion, 265·60 minutes; average speed, 26·01 miles per hour; highest rate of speed, 41·09 miles, attained on Coventry acclivity of 1 in 330. On ascending the Tring acclivity of 1 in 330, the rates of speed varied from 26·54 to 28·30 miles an hour; on descending the Tring declivity, of similar inclination, the speeds varied from 23·40 to 40 miles an hour. At the $\frac{1}{4}$ -mile distance about each stoppage the average speed was reduced to the rate of 11·46 miles an hour.

No. 20 (*general*). November 17, 1839. — Midnight train from Birmingham to London. Train, four first-class and one second-class closed carriage, two mails and post-office and tender; average gross load, 90,828 lbs. Engine, No. 61 to Wolverton, No. 15 to London: distance performed in 300·20 minutes; six stoppages, occupying together 26·25 minutes. Time in motion, 273·95 minutes; average speed throughout, 24·56 miles per hour.

No. 21 (*particular*). November 18, 1839. — From London to Watford; distance, 17·50 miles. Train, six first-class coaches, road-stations mixed coach, three mails, post-office, and truck No. 68. Engines, Nos. 4 and 17: distance performed in 46·30 minutes; one stoppage, occupying 1·06 minutes. Time in motion, 45·22 minutes; average speed, 23·22 miles; highest speed, 33·33 miles an hour, on acclivity towards Watford of 1 in 406.

No. 22 (*particular*). December 7, 1839. — From Hampton to Camden depôt; distance, 102 miles. Train, three second-class and three first-class coaches, one mail, two horse-boxes and three horses; average gross load, 90,160 lbs. Engines, Nos. 7 and 12: whole time occupied, 304·20 minutes; seven stoppages, occupying together 37·73 minutes. Time in motion, 266·47 minutes; average speed, 22·96 miles an hour; highest rate of speed, 35·71 miles, on the Coventry declivity of 1 in 330. On the acclivity from Hampton of 1 in 330, the speed varied from 21·42 to 24·19 miles an hour; and on the Coventry declivity the rates of speed varied from 22·72 miles to 35·71 miles an hour. At the $\frac{1}{4}$ -mile distance about each stopping-place the speed was reduced to an average rate of 11·70 miles an hour.

No. 23 (*particular*). December 12, 1839. — From London to Tring; distance, 31·50 miles. Train, five first-class coaches, one road-stations coach, two mails, post-office, and empty truck; average gross load, 96,788 lbs. Engine, No. 39: distance performed in 79·26 minutes; three stoppages, occupying together 5·44 minutes. Time in motion, 73·80 minutes; average speed, 25·60 miles an hour; highest rate of speed, 46·87 miles an hour, at bottom of Tring acclivity of 1 in 330, contiguous to short level plane. The lowest rate of speed on the ascent of this incline was equal to 25·86 miles per hour.

No. 24 (*particular*). December 12, 1839. — From Tring to Wolverton; distance, 20 miles. Train, two second-class and three first-class coaches, one mail, and seven carriages on trucks; average gross load, 107,736 lbs. Engine, No. 18: whole time occupied, 44·09 minutes; one stoppage at Leighton, occupying 2·65 minutes. Time in motion, 41·44 minutes; average speed throughout, 28·95 miles an hour; highest rate of speed, 41·66 miles an hour, on the declivity of 1 in 440 towards Wolverton.

No. 25 (*particular*). December 14, 1839. — From London to Watford; distance, 17·50 miles. Rails wet. Train, three second-class and four first-class carriages; average gross load, 68,464 lbs. Engine, No. 64: whole time occupied, 47·70 minutes; four stoppages, occupying together 4·07 minutes. Time in motion, 43·63 minutes; average speed throughout, 24·06 miles per hour; highest rate of speed, 34·09 miles an hour, on Tring declivity of 1 in 330. The lowest rate of speed on this incline was equal to 15·15 miles an hour.

No. 26 (*particular*). December 14, 1839. — From Watford to Coventry; distance, 75·75 miles. Train, five first-class carriages, one horse-box and one horse; average gross load, 59,860 lbs. Engine, No. 76 to Wolverton, and No. 19 from thence to Coventry: time occupied, 185·76 minutes; five stoppages, occupying together 22·40 minutes. Time in motion, 163·36 minutes; average speed throughout, 27·82 miles an hour; highest rate of speed, 40·54 miles an hour, on the Blisworth declivity of 1 in 364. The Tring acclivity of 1 in 330 was ascended at rates varying from 25 to 33·33 miles an hour. The prevailing speed was equal to 30 miles an hour.

No. 27 (*particular*). December 14, 1839. — From Coventry to Rugby; distance, 10·50 miles. Train, four second-class, three first-class carriages; average gross load, 73,440 lbs. Engine, No. 26: distance performed in 24·82 minutes; one stoppage, occupying 1·60 minutes. Time in motion, 23·22 minutes; average speed, 27·13 miles an hour; highest rate of speed, 38·46 miles an hour, on Coventry declivity of 1 in 330.

No. 28 (*particular*). December 14, 1839. — From Rugby to Birmingham; distance, 29 miles. Train, three first-class and three second-class coaches, two carriages, and one chaise on trucks, two horse-boxes and three horses, and one empty truck; average gross load, 105,364 lbs. Engine, No. 36: distance performed in 74·87 minutes; three stoppages, occupying together 11·50 minutes. Time in motion, 63·37 minutes; average speed throughout, 27·45 miles an hour; highest rate of speed, 37·50 miles an hour, on the declivity beyond the Beechwood tunnel of 1 in 330. On ascending the Coventry declivity of 1 in 330 the rates of speed varied from 18·98 to 27·77 miles per hour.

No. 29 (*general*). February 22, 1840. — From London to Birmingham, 112·25 miles; strong north-east wind. Train, five first-class carriages, two mails, and post-office; average gross load, 83,627 lbs. Engine, No. 39 to Wolverton: whole time occupied, 294·20 minutes; ten stoppages, occupying together 51·04 minutes. Time in motion, 243·16 minutes; average speed throughout, 27·69 miles per hour.

No. 30 (*general*). February 22, 1840. — From Birmingham to Camden depôt; distance, 111·25 miles. Train, four first-class carriages and one luggage-van (Grand Junction Railway); average gross load, 50,192 lbs. Engine, No. 70 to Wolverton, and No. 8 from thence to London: distance performed in 275·70 minutes; eleven stoppages, occupying together 32·73 minutes. Time in motion, 242·97 minutes; average speed throughout equal to 27·53 miles per hour.

X. London and Croydon Railway. — First and second-class gradients; locomotive engines, class E. Beyond the New Cross acclivity this line alternates in ascending and descending planes. The distance-standards are placed at intervals each of a furlong.

Experiment, No. 1 (*general*). June 21, 1839. — From London to Croydon; distance, 10·37 miles. Train, two first and three second-class carriages; average gross load, 44,960 lbs. Six-wheel engine: distance performed in 40·25 minutes; five stoppages, occupying together 6·95 minutes. Time in motion, 33·30 minutes; average speed equal to 18·68 miles an hour.

No. 2 (*particular*). June 21, 1839. — From Croydon to London; distance, 10·37 miles. Train, six carriages; average gross load, 48,972 lbs.; distance performed in 32·10 minutes; four stoppages, occupying together 2·50 minutes. Time in motion, 29·60 minutes; average speed throughout equal to 21·02 miles per hour; highest rate of speed, 37·50 miles, on New Cross declivity of 1 in 100. The descent of this plane was commenced at the rate of 30 miles; by application of the brakes it was reduced in the last half mile to the average rate of 23·07 miles an hour. At the $\frac{1}{4}$ -mile about the New Cross station the speed was reduced to the rate of 10·34 miles an hour.

No. 3 (*particular*). July 16, 1839. — From London towards Croydon; distance, 10 miles. Train, two first and three second-class carriages; average gross load, 44,960 lbs. Engine, No. 5, assisted up New Cross incline: distance performed in 36·38 minutes; five stoppages, occupying together 3·96 minutes. Time in motion, 32·42 minutes; average speed throughout equal to 18·50 miles an hour; highest speed, 28·03 miles an hour, on the New Cross acclivity. At the bottom of this incline, the speed commenced at the rate of 11·53 miles an hour, and progressed with the following rates of speed, viz. 12·50, 18·75, 22·72 (for $\frac{1}{4}$ -mile), 22·05, 18·75, 21·42, 25·00, 23·00, 22·05, and 25 miles an hour respectively.

No. 4 (*particular*). July 16, 1839. — From Croydon towards London; distance, 8 miles. Train,

three second and two first-class carriages; average gross load, 41,360 lbs. Engine, Archimedes: distance performed in 26.40 minutes; four stoppages, occupying together 2.11 minutes. Time in motion, 24.29 minutes; average speed, 19.76; highest rate of speed, 30 miles, on Annerley Bridge level plane, and on the New Cross declivity of 1 in 100. The average speed at the furlong distance about each stopping-place was reduced to 12.75 miles an hour.

No. 5 (*particular*). July 18, 1839.—From London towards Croydon; distance, 10.25 miles. Train, two first-class and three second-class carriages; average gross load, 44,060 lbs. New engine: distance performed in 37.90 minutes; five stoppages, occupying together 3.71 minutes. Time in motion, 34.19 minutes; average speed, 17.98 miles an hour; highest speed, 28.84 miles an hour, on acclivity towards Croydon of 1 in 823. In ascending the New Cross acclivity, the average rate of speed was equal to 15.50 miles an hour. At the furlong-distance about the stopping-places the average speed was reduced to 9.61 miles an hour.

No. 6 (*particular*). July 18, 1839.—From Croydon to London; distance, 10.37 miles. Train, two first and three second-class carriages; average gross load, 42,080 lbs. Engine, Surrey: distance performed in 27.64 minutes; four stoppages, occupying together 1.79 minutes. Time in motion, 25.85 minutes; average speed, 24.10 miles an hour; highest speed at the rate of 50 miles an hour on the New Cross declivity for half a mile; the speed was afterwards reduced to 21.42, and at bottom fell to an average speed of 11.90 miles an hour.

No. 7 (*particular*). July 24, 1839.—From London to Croydon. Train, two first-class and three second-class carriages; average gross load, 41,360 lbs.; distance performed in 36.90 minutes; five stoppages, occupying together 3.50 minutes. Time in motion, 33.40 minutes; average speed throughout 18.62 miles, and highest rate of speed 37.50 miles an hour on Jolly Sailor declivity of 1 in 660. At the furlong distance about each intermediate stopping-place the average speed was reduced to 9.66 miles an hour.

No. 8 (*particular*). July 24, 1839.—From Croydon to London; distance, 10.37 miles. Train, two first-class, three second-class carriages; average gross load, 40,640 lbs.; distance performed in 24.20 minutes; two stoppages, occupying together 1.67 minutes. Time in motion, 22.53 minutes; average speed, 27.61 miles an hour; highest rate of speed, 42.85 miles an hour, twice attained on the acclivity towards Croydon of 1 in 660. On descending the New Cross incline the rates of speed varied from 31.91 to 37.50 miles an hour; and at bottom, by aid of the brake, fell to an average speed of 23.07 miles an hour. At the furlong distance about each stoppage the average speed was reduced to 9.80 miles an hour.

No. 9 (*particular*). December 27, 1839.—From Greenwich junction to Croydon; distance, 8.50 miles; rails wet. Train, three second-class and three first-class carriages; average gross load, 53,472 lbs. Engine, Surrey; assisted up New Cross incline: distance performed in 26.16 minutes; four stoppages, occupying together 1.59 minutes. Time in motion, 24.57 minutes; average speed, 20.95 miles an hour; highest speed, 32.60 miles, attained on Cold Blow declivity of 1 in 1311. In ascending the New Cross incline of 1 in 100, the speed, which at bottom was 9.37 miles an hour, rose gradually to 27.77 miles, till within a distance of three furlongs from the top. The speed at the furlong distance about each stopping-place was reduced to an average rate of 8.89 miles an hour.

XI. *London and South-Western Railway*.—First and second-class gradients; locomotive engines, class E; line alternates in acclivities and declivities; distance-standards at intervals of a mile each.

Experiment, No. 1 (particular). May 21, 1838.—Line first opened to the public as far as Woking Common. From Nine Elms to Woking, chiefly ascending; distance, 22 miles. Train, five first-class

and five second-class carriages, and one truck: gross load, 103,376 lbs.; distance performed in 100 minutes: six stoppages, occupying together 9·75 minutes. Time in motion, 9·25 minutes; average rate of speed, 14·62 miles an hour; highest rate, 21·81 miles on the level plane beyond Weybridge station.

No. 2 (*particular*). May 21, 1830.—From Woking to Nine Elms; distance, 22 miles. Train, five second-class and five first-class carriages; average gross load, 96,320 lbs.; distance performed in 47·50 minutes; five stoppages, occupying together 7·50 minutes. Time in motion, 57·50 minutes; average speed equal to 22·95 miles per hour; highest rate of speed, 40 miles, on the level plane between Wimbledon and Wandsworth.

No. 3 (*particular*). Nov. 10, 1838.—From Nine Elms to Weybridge: distance, 17 miles. Train, one first and two second-class carriages; average gross load, 27,856 lbs. Engine, Tiger: distance performed in 47·50 minutes; five stoppages, occupying together 6 minutes. Time in motion, 41·50 minutes; average speed, 24·57 miles an hour; highest speed, 34·28 miles an hour, on the Wandsworth acclivity of 1 in 330. At the mile about each stoppage the average speed was reduced to 22·70 miles an hour.

No. 4 (*particular*). November 16, 1838.—From Nine Elms to Hartley Row; distance, 38 miles. Average gross weight of train, 90,000 lbs.; distance performed in 107·80 minutes; two stoppages, occupying together 7·58 minutes. Time in motion, 100·22 minutes; average speed throughout, 22·75 miles; highest rate of speed, 30 miles an hour, attained on the level planes, and on acclivities of 1 in 330 and 1 in 528. The speed was reduced about the stoppages to 15·83 miles an hour.

No. 5 (*particular*). April 8, 1839.—From Nine Elms to Walton; distance, 15 miles. Train, three second-class and two first-class carriages, one stage on truck, and one empty truck; average gross load, 58,396 lbs. Engine, Sam Slick: distance performed in 43·10 minutes; four stoppages, occupying together 4·75 minutes. Time in motion, 38·35 minutes; average speed throughout equal to 23·46 miles an hour; highest rate of speed, 36·36 miles an hour, on the level plane beyond Wimbledon station. About the stoppages the average rate of speed was reduced to 17·64 miles an hour.

No. 6 (*particular*).—From Nine Elms to Winchfield; distance, 38 miles; head-wind. Train, three first-class, three second-class carriages, three carriages on trucks, two horse-boxes and three horses; average gross load, 92,860 lbs. Engines, Jupiter and Thetis as far as Wimbledon, Jupiter alone to Woking, Mars assisted as far as Farnborough: distance performed in 127 minutes; nine stoppages, occupying together 29·95 minutes. Time in motion, 97·05 minutes; average speed equal to 23·49 miles an hour; highest rate of speed, 37·50 miles, on declivity of 1 in 330 towards Farnborough. About the stopping-places the speed was reduced on an average to 14·72 miles an hour.

No. 7 (*particular*). From Basingstoke to Nine Elms. Train, four first-class and three second-class carriages, three stages on trucks, one horse-box and one horse; average gross load, 96,132 lbs. Engine, Jupiter: distance of 38 miles from Winchfield performed in 89·25 minutes; four stoppages, occupying together 17·52 minutes. Time in motion, 71·73 minutes; average speed throughout, 31·78 miles an hour; highest rate of speed, 40 miles an hour, on the Farnborough level plane, and also on the declivity of 1 in 388 beyond Woking.

No. 8 (*particular*). August 22, 1839.—From Nine Elms to Winchfield; distance, 38 miles; strong side-wind. Train, two first, three second-class, and three excursion carriages, two horse-boxes and three horses, one carriage on truck, and one empty truck; average gross load, 109,136 lbs. Engine, Sam Slick to Woking, Chaplin assisted to Farnborough: distance performed in 127·55 minutes; ten stoppages, occupying together 26·31 minutes. Time in motion, 103·34 minutes; average speed throughout, 22·06 miles an hour; highest rate of speed, 33·51 miles on the declivity of 1 in 330 towards Farnborough station.

No. 9 (*particular*). August 23, 1839.—From Winchester to Southampton; distance, 10·50 miles.

Train, two first, two second-class, and two excursion carriages, and one stage and one omnibus on trucks; average gross load, 71,160 lbs. Engine, Locke: distance performed in 28·33 minutes; two stoppages, occupying together 1·60 minutes. Time in motion, 26·73 minutes; average speed throughout equal to 23·56 miles an hour; highest rate of speed, 31·57 miles, on the Winchester declivity of 1 in 250.

No. 10 (*particular*). August 23, 1839.—From Southampton towards Winchester; distance, 9 miles. Train, two first-class, two second-class, and two excursion carriages, omnibus on truck, one horse-box and one horse, and one laden truck; average gross load, 79,004 lbs. Engine, Locke: distance performed in 26·42 minutes; one stoppage at Twyford station, occupying ·28 minutes. Time in motion, 26·14 minutes; average speed, 20·65 miles an hour; highest speed, 31·25 miles, attained on level plane bottom of Winchester acclivity.

No. 11 (*particular*). August 23, 1839.—From 38-mile standard near Winchfield to Nine Elms. Train, two first, three second-class, one excursion carriage, five stages and omnibus on trucks, and one horse-box and one horse; average gross load, 103,596 lbs. Engine, Remorse: distance performed in 104·66 minutes; six stoppages, occupying together 14·25 minutes. Time in motion, 92·41 minutes; average speed throughout, 24·67 miles an hour; highest rate of speed, 50 miles an hour, attained on descending plane beyond Woking of 1 in 388. The speed at the mile-distance about each stoppage was reduced on an average to 12·33 miles an hour.

XII. *Newcastle and Carlisle Railway*.—Second-class gradients; locomotive engines, chiefly belonging to class E.

Experiment, No. 1 (*particular*). September 31, 1839.—From Blaydon to Haydon Bridge, 24 miles. Train, one first-class, three second-class, one mail, one horse-box and one horse, and one laden truck; average gross load, 58,563 lbs. Engine, Nelson: average pressure of steam, 48½ lbs.; distance performed in 65·67 minutes; five stoppages, occupying together 4·23 minutes. Time in motion, 61·44 minutes; average speed, 23·43 miles per hour; highest rate of speed, 37·50 miles, on Wylam acclivity of 1 in 1106. At the ¼-mile about the stopping-places the average speed was reduced to 10·94 miles an hour.

No. 2 (*general*). September 21, 1839.—From 18½-mile standard towards Carlisle. Train as last; distance performed in 44 minutes; three stoppages, occupying together 9·67 minutes. Time in motion, 34·33 minutes; average speed throughout equal to 29·27 miles an hour.

No. 3 (*particular*). September 22, 1839.—From Carlisle to Greenhead, 19·50 miles. Train, four second-class, one first-class carriage, two horse-boxes, and three horses, and one cattle-wagon; average gross load, 68,404 lbs. Engine, Wellington: average pressure, 50 lbs.; distance performed in 59·30 minutes; six stoppages, occupying together 8·72 minutes. Time in motion, 50·58 minutes; average speed throughout, 23·13 miles an hour; highest rate of speed, 37·50 miles an hour. On the Low Row level plane, ascending the acclivity of 1 in 106 between Wetherall and Milton station, the speed at bottom, which was 20·54 miles an hour, rose to 25 miles, and was not at a lower rate throughout than 17·64 miles an hour. The average speed during the ascent was equal to 23·50 miles an hour; on the level plane the speed averaged 32 miles an hour.

No. 3 a (*particular*). September 22, 1839.—From Haydon Bridge to Blaydon; distance, 24 miles. Same train: distance performed in 77 minutes; eight stoppages, occupying together 16·70 minutes. Time in motion, 60·30 minutes; average speed, 23·88 miles an hour; highest rate of speed, 39·47 miles, on plane of 1 in 423, descending from the summit.

No. 4 (*particular*). October 15, 1839.—From Carlisle to Milton; distance, 9·75 miles; rails wet. Train, twenty-six empty coal-wagons; gross load, 93,184 lbs. Engine, Goliath: average pressure of

steam, 43 lbs.; distance performed in 67·68 minutes; one stoppage, occupying 28·95 minutes. Time in motion, 38·73 minutes; average speed, 15·10 miles per hour; highest rate of speed, 22·38 miles an hour on an acclivity towards Milton of 1 in 176. On the acclivity of 1 in 106 the speed varied from 11·90 to 17·64 miles an hour, the average speed being equal to 12 miles an hour.

No. 5 (*particular*). October 15, 1839.—From Greenhead to Carlisle; distance, 18·25 miles. Train, one first-class and one second-class carriage, one mail, one luggage-van, one gig on truck, one horse-box and one horse, three trucks partly laden; average gross load, 56,196 lbs. Engine, Cumberland: average pressure of steam, 50 lbs.; distance performed in 56·65 minutes; five stoppages, occupying together 8·29 minutes. Time in motion, 48·36 minutes; average speed, 22·64 miles per hour; highest speed, 35·71 miles, on the declivity of 1 in 106; the average speed on this descent was equal to 28 miles an hour.

No. 6 (*particular*). October 15, 1839.—From Milton to Greenhead; distance, 8·50 miles. Train, two second-class, one first-class carriage, one luggage-van with seats, one horse-box with one horse, one luggage-van, and two trucks of merchandise; average gross load, 55,804 lbs. Engine, Cumberland: average pressure, 50 lbs.; time occupied, 25·73 minutes; two stoppages, occupying together 2·30 minutes. Time in motion, 23·43 minutes; average speed, 21·76 miles an hour; highest rate of speed, 31·91 miles an hour, on the level plane between 13 and 19 miles from Carlisle depôt.

No. 7 (*particular*). October 17, 1839.—From 21-mile standard towards Carlisle; 9·25 miles. Train, one luggage-coach, two second-class coaches, one mail, one horse-box, one horse, and one cattle-truck. Engine, Hercules: average pressure, 48 lbs.; distance performed in 29·77 minutes; two stoppages, occupying 7·33 minutes. Time in motion, 24·73 minutes; average speed, 24·73 miles an hour; highest rate of speed, 42·85 miles an hour, on the level plane between Greenhead and Milton.

No. 7 *a* (*particular*). Same train and engine; whole distance from Carlisle; 19 miles; whole time occupied, 66·87 minutes; three stoppages, occupying together 11·93 minutes. Time in motion, 54·94 minutes; average speed, 20·74 miles an hour; highest rate of speed, 42·85 miles, on the level plane. On the descent of 1 in 106 the speed at top was equal to 30 miles an hour, and increased towards the bottom to 38·46 miles an hour.

No. 8 (*particular*). October 17, 1839.—From Carlisle to 15-mile standard; distance 13 miles. Train, one first-class carriage, two second-class, one luggage-van, one horse-box and one horse; average gross load, 41,300 lbs. Engine, Wellington: average pressure of steam, 50 lbs.; distance performed in 32·23 minutes; two stoppages, occupying together 1·38 minutes. Time in motion, 30·85 minutes; average speed, 25·28 miles an hour; highest rate of speed, 41·66 miles on a level. In ascending the acclivity of 1 in 106 the speeds varied from 37·50 miles at bottom, to 21·42 miles an hour towards the top.

No. 9 (*particular*). October 18, 1839.—From Carlisle to Greenhead; distance, 19·50 miles; strong head-wind. Train, two second-class, one first-class carriage, one mail, one luggage-van, one horse-box and one horse, and one chaise on truck; average gross load, 54,572 lbs. Engine, Nelson: average pressure of steam, 48 lbs.; distance performed in 58·68 minutes; four stoppages, occupying together 9·25 minutes. Time in motion, 49·43 minutes; average speed, 23·67 miles an hour; highest rate of speed, 33·33 miles, on the level plane between Milton and Rosehill. Ascending the acclivity of 1 in 106 the speeds were about 22 miles an hour throughout. At the $\frac{1}{4}$ -mile distance about each stoppage the speeds were reduced, on an average, to 11·65 miles an hour.

No. 10 (*particular*). October 18, 1839.—From Greenhead to Carlisle; distance, 19·50 miles. Train, one first-class, two second-class carriages, one horse-box, and one luggage-coach; average gross load, 41,300 lbs. Engine, Wellington: average pressure of steam, 50 lbs.; distance performed in 43·11 minutes; three stoppages, occupying together 4·10 minutes. Time in motion, 39·01 minutes;

average rate of speed, 29.99 miles; highest rate of speed, 41.66 miles an hour, which was attained on the declivity of 1 in 106. The lowest rate of speed in this descent was equal to 33.33 miles per hour.

XIII. North Union Railway.—Second-class gradients; locomotive engines, class E 1. Line alternates in acclivities and declivities.

Experiment, No. 1 (general). January 15, 1839. From Parkside towards Preston; distance, 22 miles. Train, two first, and three second-class carriages; average gross load, 43,880 lbs. Four-wheel engine; distance performed in 71 minutes; five stoppages, occupying together 13 minutes. Time in motion, 58 minutes; average speed throughout equal to 22.75 miles an hour.

No. 2 (general). August 1, 1839.—From Parkside to Preston; distance, 22.25 miles. Train, three first and three second-class carriages; average gross load, 54,012 lbs. Engine, No. 5: distance performed in 66.50 minutes; seven stoppages, occupying together 8.62 minutes. Time in motion, 57.88 minutes; average speed throughout, 23.06 miles per hour; highest rate of speed, 34.88 miles an hour, on level plane, 5 miles from Parkside.

No. 3 (particular). November 20, 1839.—From Preston to Parkside; distance, 22.25 miles. Train, three first-class, three second-class carriages; average gross load, 53,472 lbs. Engine, No. 4: distance performed in 63 minutes; seven stoppages, occupying together 7.54 minutes. Time in motion, 55.46 minutes; average speed, 24.07 miles an hour; highest rate of speed, 40.54 miles an hour, attained on second declivity of 1 in 100, between Parsonage Lane and Wigan. Commencing at Preston, the speeds attained on the first acclivity of 1 in 100 were respectively 27.27 and 25.86 miles an hour; on the second, just after leaving Leyland station, 14.70 and 18.07 miles an hour; on the third, 30, 25, and 22.05 miles an hour respectively; on the fourth, 24.59 and 24.19 miles respectively. On the fourth leaving Coppull station, an average speed of 17.64 miles an hour was attained. On the first declivity the speeds were 27.27 and 31.25 miles an hour respectively; on the second declivity, 33.33, 36.58, and 35.71 miles an hour respectively; on the third declivity, 40.54 (already quoted) and 37.54 miles an hour: the fourth declivity is at the Wigan station, the average speed about which, for a quarter of a mile, was reduced to 13.88 miles.

No. 4 (particular). November 20, 1839.—From Parkside towards Preston; distance, 17.50 miles. Train, two first-class and three second-class carriages; average gross load, 43,160 lbs. Engine, No. 4: distance performed in 44.58 minutes; four stoppages, occupying together 3.02 minutes. Time in motion, 41.56 minutes; average speed throughout equal to 25.26 miles an hour; highest rate of speed, 42.85 miles, on the declivity of 1 in 100, between eight and nine miles from Preston. About the Wigan stoppage the average speed was reduced to 15 miles an hour. The following rates of speed were attained on acclivities of 1 in 100: 21.42, 18.75, 22.38, 22.05, 21.42, 27.27, and 25.42 miles an hour respectively. On the declivity towards Coppull the speeds of 31.91 and 33.33 miles an hour were respectively attained.

No. 5 (general). November 22, 1839.—From Preston towards Parkside; distance, 22 miles. Train, three first-class carriages and post-office; average gross load, 46,380 lbs. Engine, No. 4: distance performed in 51.90 minutes; two stoppages, occupying together 6.80 minutes. Time in motion, 45.10 minutes; average speed, 29.26 miles an hour.

No. 6 (particular). November 28, 1839.—From Parkside towards Wigan; 2.50 miles; excessive cold prevented the figures being noted down beyond the 2½ miles. Train, two first-class carriages; gross load, 22,424 lbs. Engine, No. 4: average pressure of steam, 52½ lbs.; distance performed in 5.40 minutes; no stoppage. Average rate of speed, 27.77 miles an hour; highest rate of speed, 32.60 miles, on declivity of 1 in 440.

No. 7 (particular). November 28, 1839.—From Wigan to Parkside; distance, 6.25 miles. Train,

two first-class and three second-class carriages, two horse-boxes and three horses; average gross load, 55,800 lbs. Engine, No. 6: average pressure of steam, 50 lbs.; distance performed in 12 minutes; no stoppage. Average speed, 31.25 miles an hour; highest rate of speed, 37.50 miles an hour, on descending plane of 1 in 406.

XIV. Stockton and Darlington Railway. Second-class gradients; gradual ascent from Stockton to summit of line beyond Shildon; passenger-engines, class E.

Experiment, No. 1 (particular). October 25, 1839.—From Stockton to Darlington; distance, 11.25 miles. Train, one first-class, two second-class, one mixed carriage, and one luggage-coach with seats on top; average gross load, 39,180 lbs. Engine, Arrow: average pressure of steam, 50 lbs.; distance performed in 31 minutes; two stoppages, occupying together 1.40 minutes. Time in motion, 29.60 minutes; average speed, 22.80 miles an hour; highest rate of speed, 34.09 miles, on acclivity of 1 in 1408. On acclivity of 1 in 104, leaving Stockton, the average speed was at the rate of 12.50 miles an hour. On the acclivity of 1 in 226, the average speed was 24.19 miles; and on that of 1 in 204, towards Fighting Cocks, 25 miles an hour respectively. At the $\frac{1}{4}$ -mile about each stoppage the average rate of speed was reduced to 10.36 miles an hour.

No. 2 (particular). September 25, 1839.—From Stockton to Darlington; distance, 11.25 miles. Strong side-wind; rails wet. Train, two second-class, one first-class, one mixed, and one luggage-coach, and Yorkshireman stage-coach (railway mounted); average gross load, 46,236 lbs. Engine, Sunbeam: average pressure of steam, 50 lbs.; distance performed in 42.50 minutes; two stoppages, occupying together 1.65 minutes. Time in motion, 40.85 minutes; average speed, 16.52 miles an hour; highest speed, 30 miles an hour, on acclivity of 1 in 713. On the Stockton acclivity of 1 in 104 the average speed was 6.38 miles an hour.

No. 3 (particular). September 25, 1839.—From Darlington to Shildon; distance, 7.25 miles. Strong side-wind. Train, two coaches. Engine, Arrow: average pressure of steam, 50 lbs.: distance performed in 20.40 minutes; two stoppages, occupying together 1.67 minutes. Time in motion, 18.73 minutes; average speed, 23.22 miles an hour; highest rate, 33.33 miles, on acclivity of 1 in 352. On the acclivity of 1 in 105 the speed varied from 16.30 to 32.60 miles an hour; and on that of 1 in 138, from 20 to 30 miles an hour, being 30 miles at top. On the acclivity to Shildon, of 1 in 128, the lowest speed, except at top, was 25 miles an hour; and the average speed, 30 miles an hour.

No. 4 (particular). September 25, 1839.—From Shildon towards Stockton, descending; distance, 18.50 miles; strong side-wind. Train from Shildon to Darlington, one second-class and one mixed carriage (17,496 lbs.), one luggage-coach and one mixed carriage added at Darlington (average gross load from Darlington, 34,900 lbs.). Engine, Arrow: average pressure of steam, 50 lbs.; distance performed in 51.50 minutes; four stoppages, occupying together 7.67 minutes. Time in motion, 43.83 minutes; average speed throughout, 25.32 miles an hour; highest rate of speed, 42.85 miles an hour, on declivity of 1 in 1408, between 9 and 10 miles from Stockton. On descending the Shildon declivity of 1 in 128, the speed rose from 8.19 to 37.50 miles an hour. On that of 1 in 135, beyond Aycliffe Lane, it varied from 25 miles to 30 and 37.50 miles an hour respectively; and on the Darlington declivity of 1 in 105 the speed rose from 21.42 to 37.50 miles an hour.

No. 5 (particular). September 26, 1839.—From Stockton to Darlington; distance, 11.25 miles. Train, three second-class, one first-class, and one luggage-coach; average gross load, 37,832 lbs. Engine, Arrow: average pressure of steam, 50 lbs.; distance performed in 32 minutes; two stoppages, occupying together 2.15 minutes. Time in motion, 29.85 minutes; average speed, 22.61 miles

an hour; highest rate of speed, 37·50 miles an hour, on acclivity of 1 in 1584. About stoppages (taking the $\frac{1}{4}$ -mile distance) the average speed was reduced to 11·50 miles an hour.

No. 6 (*particular*). September 26, 1839. — From Darlington to Stockton; distance, 11·25 miles. Train, same as last. Engine, Arrow: distance performed in 29·80 minutes; two stoppages, occupying together 1·52 minutes. Time in motion, 28·28 minutes; average speed equal to 23·86 miles an hour; highest rate of speed, 37·50 miles, on declivity of 1 in 2112, towards Yarm station. At top of the Stockton declivity of 1 in 104, the speed was 25·86 miles, but reduced to an average at bottom of 12·96 miles an hour. About the stoppages the speed was reduced to an average rate of 13·99 miles an hour.

XV. York and North Midland Railway.—First-class gradients; engines, class E; distance-standards at $\frac{1}{4}$ -mile intervals.

Experiment, No. 1 (*general*). August 3, 1839. — From Leeds junction to York; distance, 14 miles. Train, one first, one second, and one third-class carriage; average gross load, 28,256 lbs. Engine, Lowther: distance performed in 39·95 minutes; four stoppages, occupying together 5·35 minutes. Time in motion, 34·60 minutes; average speed, 24·27 miles an hour.

No. 2 (*particular*). August 3, 1839. — From York to Leeds junction; distance, 14 miles. Train, one third-class, two first-class, one second-class carriage, two trucks and two wagons, partly laden; average gross load, 82,836 lbs. Engine, York and Leeds: distance performed in 46·12 minutes; four stoppages, occupying together 4·30 minutes. Time in motion, 41·82 minutes; average speed equal to 20·06 miles an hour; highest rate of speed, 34·09 miles an hour, on acclivity of 1 in 1056. At the $\frac{1}{4}$ -mile about each stoppage the average speed was reduced to 8·95 miles an hour.

No. 3 (*general*). October 26, 1839. — From Leeds junction to York; distance, 14 miles. Train, three second-class, two first-class, and one third-class carriage; average gross load, 60,256 lbs. Engine, Lowther: distance performed in 37·60 minutes; two stoppages, occupying together 2 minutes. Time in motion, 35·60 minutes; average speed, 23·59 miles an hour.

No. 4 (*particular*). October 27, 1839. — From York to Leeds junction; distance, 14 miles. Train, one third-class, one second-class, one first-class, and one mixed coach, and three trucks, partly laden with merchandise; average gross load, 62,526 lbs. Engine, York and Leeds: distance performed in 41·20 minutes; two stoppages, occupying together 3·13 minutes. Time in motion, 38·07 minutes; average speed, 22·06 miles an hour; highest rate of speed, 32·60 miles an hour, on level plane, 5 miles from York. The speed at the $\frac{1}{4}$ -mile about each stoppage averaged 13·25 miles an hour.

No. 5 (*particular*). October 29, 1839. — From Leeds junction to York; distance, 14 miles. Train, one first, one second, one third-class carriage, and truck with luggage; average gross load, 33,856 lbs. Engine, York and Leeds: distance performed in 40·90 minutes; two stoppages, occupying together 2·20 minutes. Time in motion, 35·50 minutes; average speed, 23·66 miles an hour; highest rate, 35·71 miles an hour, on declivity of 1 in 1320.

No. 6 (*general*). October 29, 1839. — From York to Leeds junction; distance, 14 miles. Rails wet. Train, two first-class, one second-class, and one third-class coach; average gross load, 33,344 lbs. Engine, York and Leeds: distance performed in 40·90 minutes; two stoppages, occupying together 1·80 minutes. Time in motion, 39·10 minutes; average speed throughout, 21·48 miles an hour.

NOTE.—For the direction of each railway on which the above experiments were made, see the Railway Plan (Plate 17).

CONCLUSION.—From the foregoing experiments we obtain some important results as regards the original laying out and first cost of railways. On some of the main lines an enormously increased expenditure has been incurred, for the purpose of obtaining first-class gradients throughout; yet, in the every-day working of railways, we find that as high, and in some instances higher, average rates of speed are maintained throughout each trip on lines having a great proportion of gradients under the first class.

The London and Birmingham Railway is a forcible example of excessive first cost; occasioned, in a great degree, by excluding second-class gradients; yet in the thirty-two practical experiments made on that line, and described above, the average speed maintained throughout was equal to only 24·69 miles an hour; whereas on the Grand Junction line, where second-class gradients were introduced for the express purpose of keeping down the original cost, the average speed maintained throughout twenty-four experiments was equal to 26·20 miles an hour.

On the Newcastle and Carlisle, North Union, and Stockton and Darlington Railways, each of which has second-class gradients, and some of the highest degree, the results as to the first and second are equally favourable, and on the third nearly so.

On the Newcastle and Carlisle Railway, which, in addition to some second-class gradients, is made up of a series of quick curves almost from end to end, the average speed maintained throughout eleven experiments was equal to 24·41 miles an hour.

On the North Union Railway, one-fourth of the length of which is graduated with the highest degree (1 in 100) of second-class gradients, the average speed throughout was equal to 26·20 miles an hour.

On the Stockton and Darlington Railway, which is entirely an ascending line in one direction, and has also a great proportion of second-class gradients, the average speed maintained throughout six experiments was equal to 22·38 miles an hour. This last and less favourable result is partly to be attributed to the fuel being of less calorific value, and partly to the Stockton terminal plane being on an acclivity of 1 in 104 for upwards of a mile in length. Nothing can shew a greater want of judgment in laying out a railway to be worked by locomotive engines, than making either of the terminal planes on a steep acclivity; either a level plane, or, better, a declivity of

short length, should always be introduced at the terminal stations; and at the intermediate stations a level plane, if possible, but on no account a steep inclination. In the case of the terminal planes, the *declivity* is required for *starting* the engines, and the *acclivity* for *checking* their velocity on arrival; but at the intermediate stations the case is different, as the engines approach them from either side.

There are three cases particularly bearing on the point, which we shall here mention. The first, the London terminal plane of the South Western Railway; the second, the Stockton terminal plane of the Stockton and Darlington Railway; and the third, the New Cross incline on the London and Croydon Railway.

On the London terminal plane of the South Western Railway, although on an acclivity of only 1 in 330 (the maximum of first-class gradients), the speed for the first mile is always reduced to a very low figure. In experiment No. 1 on this line, the speed for the first mile from Nine Elms was at the rate of only 6·66 miles an hour; in experiment No. 3, 13·33 miles an hour; in experiment No. 4, 9·09 miles an hour; in experiment No. 5, 15·38 miles an hour; in experiment No. 16, 10·16 miles an hour; and in experiment No. 8, 13·18 miles an hour, giving an average speed in ascending this terminal acclivity of only 11·52 miles an hour.

As to the second, or Stockton acclivity, of 1 in 104:—In experiment No. 1, the speed for the first mile was at the rate of 12·50 miles an hour; in experiment No. 2, 6·38 miles an hour; and in experiment No. 5, 14·56 miles an hour, giving an average of 11·14 miles an hour.

As to the third, or New Cross incline, which rises immediately from the New Cross station, it is found necessary to have an extra engine constantly in waiting to assist the passenger-trains up this acclivity. We may quote one example of the speeds attained on leaving the New Cross station. In experiment No. 7, the first *eighth* of a mile was performed at the rate of 9·37 miles an hour, the second eighth at 12·50, and the third eighth at 16·16 miles an hour; whereas, when the train reached the thirteenth standard, the speed was as high as 30 miles an hour.

In comparing velocities on railways differently graduated, we must take the mean velocity of the ascending and descending trains. As, for example: on the London and Birmingham Railway we found the average velocity, in

ascending the inclines of 1 in 330, from a variety of trials, to be equal to 28·11 miles an hour; and in descending similar inclines, equal to 32·62 miles an hour: taking the mean of these results, we have an average speed for the maximum of the first-class of gradients of 30·36 miles an hour.

Again: on the Madeley incline of the Grand Junction Railway, having a second-class inclination of 1 in 177, the average ascending speed (with as many trials as made on the London and Birmingham 16-feet inclines) we found to be equal to 22·65 miles an hour, and the average descending speed to 41·69 miles an hour. The mean of these results is 32·17 miles an hour.

We shall only further adduce instances of ascending and descending velocities on the maximum of the second-class gradients, or 1 in 100. The best example we can bring forward is that of the North Union Railway, one-fourth of the length of which has inclinations of 1 in 100. We found by several trials that the average ascending velocity was equal to 20·44 miles an hour, and the average descending velocity to 34·57 miles an hour. The mean of these results is 27·50 miles an hour. In laying out a railway, however, with second-class gradients, care must be taken not to introduce inclines of the maximum inclinations of greater length than from half to three-quarters of a mile; and if a continued series of steep inclines is rendered necessary, in order to attain a lofty summit in a short distance, it is very desirable to separate these inclines by level planes, however short, in preference to inclines of any degree.

In attaining a lofty eminence by steep grades interspersed with short level planes, a locomotive engine may be compared to a horse: the one is thus enabled to recover, as it were, its steam at certain intervals of the ascent, and the other its wind.

With regard to intermediate stoppages, it will be seen throughout the experiments that much power is absorbed, and time occupied, on every railway, however well managed; and we look forward confidently to the time when each stoppage on "the way" will be rendered nearly of certain duration, and not exceed a maximum of five minutes in any instance.

THE
RECIPROCATING SYSTEM OF RAILWAYS.

IN March 1839 we submitted to the Institution of Civil Engineers the outline of a proposed new system of laying out and working railways, which, from the peculiar method proposed of carrying on the traffic, we have designated the Reciprocating System. Had this plan emanated from a Stephenson or a Brunel, it would, no doubt, ere this have been carried into execution. So much, however, are we convinced of the efficacy of the system, from the results of our examination and experiments on the principal railways of the kingdom, that we have no hesitation in at once laying it before that large and increasing portion of the British people who are so greatly interested in every improvement that can reduce the original cost of railways, and thus extend the system to those parts of the country in which money is not so plentiful as in the great manufacturing districts, and where the introduction of railways would tend greatly to ameliorate the condition of the people, and, without doubt, afford an ample return for the much-reduced outlay.

The present expensive mode of constructing railways is quite incompatible with their further extension ; and unless an economical and, at the same time, efficient system is introduced, a large mass of the population of the United Kingdom will be for ever debarred of the comforts and conveniences afforded directly to those places which are included in the catalogue of railway cities, towns, or districts.

We shall divide the account of the Reciprocating System into three parts, viz. 1st, construction of railways according to this system ; 2d, method of carrying on the traffic ; and, 3d, the estimated cost and annual expenditure.

The peculiar feature proposed in the construction of railways according to the reciprocating plan, is the adoption of a single line of way throughout, whatever may be the expected amount of traffic ; by which the original cost

of the earthworks, masonry, and upper works of railways so constructed, would necessarily be reduced to a considerable extent; and, further, to introduce in undulating or hilly districts of country a considerable proportion of second-class gradients, and, where necessary for the sake of avoiding heavy earthworks, tunnels, or expensive viaducts or bridges, even third-class gradients, where such inclines could be introduced of short length.

In order that the whole system may be thoroughly understood, we shall describe *seriatim* the mode of construction under the following heads, viz.:—

1. Land and Fencing; 2. Earthworks; 3. Drainage; 4. Tunnels, Viaducts, and Bridges; 5. Level Crossings; 6. Permanent Way; and 7. Stations and Depôts.

1. LAND AND FENCING.—The land is to be enclosed throughout to an uniform width of 34 feet, where within a foot of the surface of the lands, or where carried on embankment, exclusive of that for slopes, sidings, and stations or depôts, $9\frac{1}{2}$ feet of which, on each side, is for the fence, bank, ditch, and benches. In the case of cuttings, an additional width of $3\frac{1}{2}$ feet on each side is to be provided for a field-drain at top of the slope, and 3 feet for the extra width under ballasting.* For each siding, an additional width of 5 feet on each side is to be enclosed for a length of 360 feet; and four such additional parcels of land are to be enclosed in each mile. Besides which, at every intermediate station there is to be an additional way of 450 feet in length, for which an extra width of land is to be enclosed (see Plate 2, figs. 2 and 3). The fencing, in districts where stone is abundant, as in the West Riding of Yorkshire, in Westmorland, and in parts of Lancashire, Wales, and Scotland, &c., is to be constructed of dry stone-walling, with coping rounded on top, and laid in mortar (see fig. 25, Plate 16). In other districts, where wood is obtained at a much cheaper rate than stone, stout oak or larch cleft-posts with three rails, and dwarf space-and-pale fencing (see Fig. 30, Plate 16) is to be introduced, with a planting of quick along the top of the bank, which is to be formed from the side-drain. The field-gates may either be of iron or wood (see figs. 32 and 33, Plate 16), according to the custom

* This will afford space between the rail and the ditch for workmen to get out of the way of the passing trains.

of the particular district. All the posts are to be charred to a height of 3 inches above the ground-level.

2. EARTHWORKS.—The top width of embankments to be 15 feet (Plate 2, fig. 6), and the clear width of cuttings between the side-drains to be 18 feet (Plate 2, fig. 7); the slopes of cuttings and embankments throughout to be regulated by the description of strata intersected. In plastic clays and in loams the slopes will generally stand at from 2 to 1 to 3 to 1; the embankments requiring, in most cases, the less amount of slope of the two. In gravel and in indurated sands the slopes will stand at $1\frac{1}{2}$ to 1. In solid chalk the cuttings may be formed at one-sixth to one; and the embankments formed from the produce of such cuttings at from 1 to 1 to $1\frac{1}{2}$ to 1. In disrupted chalk the cuttings will stand at from $1\frac{1}{2}$ to $\frac{1}{2}$ to 1. It is advisable in deep chalk, or other cuttings, to carry up the slopes from the bottom, according to the strata as above, for two-thirds the height when it is as much as 40 feet, and then run a bench 6 feet in width, with an open drain, or water-course, along the middle, to receive the surface-water from the lands, which may be carried into the lower drains by earthen pipes, or well-pitched wooden trunks, of a size to be regulated by the flow of water, which may be generally ascertained by reference to the neighbouring water-courses. Above the bench, the slope to be formed at $\frac{1}{2}$ to 1, where the lower slope is at $\frac{1}{2}$; or at $\frac{1}{2}$ to 1, where the lower slope is at $\frac{1}{4}$. In red sandstone, and other solid rocks, the sides of the cuttings will be perpendicular.

In forming embankments of clays, loams, or any loose and doubtful materials, when they exceed 10 feet in height, they are to be carried up in layers, or courses, each of from $1\frac{1}{2}$ to 2 yards in thickness. The whole of the bottom layer, whether formed from a cutting at each end, or from a cutting at one end only, or from side-cutting, is to be completed throughout before the next layer is superposed.

Although this method will considerably increase the first cost of embankments formed of treacherous soils, yet it will save a large annual outlay in the shape of "repairs to slopes," and entirely prevent accidents from the permanent way being disturbed by slips of the uncertain materials of which some of the embankments will necessarily be formed. By the ordinary mode of constructing embankments, large cavities are left in the body of the work,

which presently form reservoirs for the water percolating from the surface, and thus channels are effected; slips are continually taking place, and the permanent way is sinking daily for years after, so that the items of "maintenance of way," and "repairs to slopes," form a large amount in the annual expenditure.

By the above-described method, each layer is well trodden down, and exposed to the weather for a sufficient time till it becomes consolidated, before the next layer is superadded. We do not recommend the earthworks to be executed by night, as they are generally less attended to by the work-people than in the daytime; but rather that they should be carried on simultaneously, and not too hastily; and if money is not plentiful, then we would let to contractors so many layers of the embankments from end to end. Thus the bottom layer of each embankment throughout would become consolidated nearly at the same time, depending of course on the lengths respectively. Side-cutting and spoil-banks must be resorted to where the length of the lead would render it more expensive to form the embankments from the regular cuttings. Where side-cutting is rendered necessary, the most advisable plan is to run side-dykes parallel to the embankments, which tend to keep them solid by being thus well drained. The height to which spoil-banks should be carried must depend upon the value of the land where they are to be placed; but a good plan is to increase the width of the contiguous embankments, provided the lead is not of too great length. Earthworks, formed according to the general plan, and taken throughout the kingdom, cost at from 6*d.* to 1*s.* 6*d.* per cubic yard. The average cost is about 14*d.* per cubic yard.

3. DRAINAGE.—Lateral drains are to be formed parallel to all the cuttings and embankments; to be generally 3 feet wide at top, 1 foot at bottom, and 1½ feet deep. At the top of the slopes of cuttings an open drain is also to be formed, 2 feet 6 inches wide and 1 foot 3 inches deep, the produce of which (if the soil is of proper quality) is to form a bank for the quick plantings, which in course of time will become the permanent fence; but where the fences are of stone, this will not be required: in such case the excavated earth from the top-drains will go, with the produce of the cutting, to form the contiguous embankments, or carried to spoil, as the case may be.

Where cuttings are deep, and there is a great flow of water, it will be necessary to introduce open semicircular drains of brick (see fig. 17, Plate 16), or open square drains of stone, paved at bottom with flags, if in a stone district; and in extreme cases culverts will be necessary (see Plate 16), with eyes or openings from the surface, according to the plan adopted in the great Tring cutting of the London and Birmingham Railway. In stone districts a rubble-drain should be formed down the centre-line of both cuttings and embankments, and lateral rubble-drains or soughs carried therefrom into the side-drains; or where the embankments are high, into open slope-drains, formed either of flags, semicircular open brickwork, or wooden well-pitched troughs, the dimensions in all cases to be regulated by the circumstances of each particular case. Slope-drains must also be introduced in deep cuttings to carry the water from the top-drain into the lower water-channel. In districts where brick earth is plentiful, the best kind of sub-water-courses are formed of perforated circular tile-drains, as iron pipes constructed spigot-and-faucet fashion (see fig. 19*a*, Plate 16).

4. TUNNELS, VIADUCTS, AND BRIDGES.—The clear width of tunnels at level of rails to be 12 feet, and the clear height from level of rails to soffit 18 feet (fig. 5, Plate 2); the vertical working-shafts to be of 7 feet clear diameter, and at intervals each of a quarter of a mile, and to be left open at top when finished, for the purposes of ventilation; but a circular roof of 13 feet diameter to be elevated on light iron columns 6 feet above the top of shaft, to throw off the rain-water, which would otherwise fall into the tunnel. The ground about the top of each shaft to be sloped off to carry the surface-water away from the shafts. The vertical shafts through most strata will require to be lined with 9-inch brickwork; and on no account should cavities be left behind the lining, but in all such cases the work is to be keyed in and wedged up solid to the required thickness. Iron curbs of 7 feet clear diameter, formed in two parts, must be introduced on the roof of the tunnel to support the shafts. The produce of the shafts' excavation, and afterwards of the adit or drift-way, and subsequently of the tunnel itself, to be drawn up by double horse-gins, or in coal districts by steam-engines, or in mountainous districts, where water is abundant, by water-wheels. When the shafts are sunk to the level of the bottom

of the tunnel, a drift-way, 3 feet wide and 5 feet high, is to be driven from shaft to shaft throughout, for draining the works. In moist soils this adit will require to be shored up with wooden struts, cross sills, head-plates and struts, and planked at top.

When the vertical shafts and adit are completed throughout, the tunnel may be commenced. None of the tunnels to be formed with level planes, but having a sufficient inclination in either direction, or in both directions, from the middle, to carry off the water. A movable frame with three floors will be convenient for carrying on the excavation, and brick or stone lining, where required. This frame should correspond nearly with the clear size of the tunnel, and be mounted on six wheels, three on each axle, and the middle one of each set to be without flanches. Three strong single parallel rails to be laid down on cross sleepers, the outer rails to be 10 feet apart; the rails must not be in longer lengths than of 5 feet, so that they may be laid down from the lower floor as the excavation proceeds. The front of this frame to be furnished with three stout flaps hung from the top, which may be let down in cases where blasting by gunpowder is required, the frame in such case to be run back to a convenient distance; in case also of the appearance of a slip of earth, the men may run to the back part of the floor, and let down the flaps to protect themselves from injury.

When brickwork is used as the lining for the tunnel, it will require in most cases to be of two bricks in thickness; and except the invert, the whole is to be built in Roman cement and sharp river-sand (if to be had conveniently). No cavities are to be left behind the brickwork, nor loose or doubtful soil, which should be removed, and the space filled in with solid brickwork. Lateral recesses, 3 feet wide, 3 feet deep, and 6 feet long, are to be formed in the tunnel at intervals each of 30 yards, for the workmen to get out of the way of the train when the railway is opened for traffic. A stone springing course will be required at the meeting of the side-walls and the invert. The invert (where required) is to be built of segmental form, with a versed sine sufficient to allow of a drain being carried the whole length of tunnel, at least 12 inches under the level of the rails. The permanent rails through the tunnels to be laid on half timbers or half baulks, and secured together by cross-ties dovetailed into the longitudinal timbers, and secured thereto by screw bolt-ties and nuts. The tunnel-faces to be of plain and neat design;

a fire-place and chimney of brick; but where brickwork is built at a low rate, as in Ireland, then the lodges may be built of brick, and in stone districts of rough-tooled stonework.

In forming occupation level-crossings, a cattle-arch of 6 feet wide and 7 feet high should also be introduced, as on the Birmingham and Derby, and Northern and Eastern Railways: lodges are of course not required to be built at these crossings. When it is practicable to bring a number of field-gateways on each side into a side occupation-lane formed for the purpose, it is desirable to build a bridge over or under the railway, as the case may be, thereby avoiding several level crossings, besides the additional cattle-arches.

6. PERMANENT WAY.—The gauge of way is proposed to be of 5 feet in new districts; but if the intended line is to join any other railway, it must of course correspond with the gauge of that line. The rails, chairs, pins, keys, felt-blocks, sleepers, and ballasting, constitute the permanent way, or upper works of railways.

The rails throughout the cuttings and tunnels are to be of the bridge-form, weighing about 56 lbs. to the yard lineal, nearly similar in cross section to fig. 24, Plate 3, and laid with an intermedium of felt on longitudinal timbers of American pine, (bethellized and coated externally with Stockholm tar,) 12 inches on bed by an average thickness of 6 inches, two timbers being cut out of a whole baulk (see fig. 2, Plate 16), so that the rails are fixed with a slight inclination inwards, and secured thereto by screws similar to those used in the permanent way of the Great Western line (see fig. 4, Plate 16). The whole of the screws to be immersed in boiling linseed oil for 48 hours before being used, and the number to each 15-foot rail to be twenty-four. Cross ties of old ship-oak, 8 inches by 4 inches (where it can be obtained at a moderate cost), to be introduced between, and dovetailed into, the longitudinal timbers at intervals of 6 feet, and secured thereto by screw-ties, according to the section fig. 2, Plate 16.

On embankments, shallow parallel rails (see Plate 3, fig. 7), weighing 56 lbs. to the yard, are to be entirely used, to be fixed in chairs, the sockets of which are to correspond in shape with the lower part of the rail, leaving only sufficient space for inch-deal wedges, thus getting rid of large keys or other fastenings altogether. The chairs are to be secured with War-

no ornamental work to be introduced on any account, except the tunnel be carried under part of a park or ornamental grounds. The surface-water above the tunnel near either end is to be carried into the drains of the contiguous cuttings by open semicircular drains of brick or stone, according to the district.

BRIDGES AND VIADUCTS.—The bridges carrying roads over the railway are to be of a clear span of 12 feet, and clear height from rails to soffit of $15\frac{1}{2}$ feet in the middle of way (fig. 4, Plate 2). The arches to be of segmental form, with a versed sine of 3 feet; to be built (where bricks are used) in four half-brick rings. A central semicircular drain (fig. 19, Plate 16) to be carried under the permanent way, of a size in proportion to the depths of the contiguous cuttings.

In bridges carrying the railway over roads, rivers, canals, &c. the clear width between the parapets is to be 12 feet; and except where adjoining lofty embankments, the parapets are to be only 18 inches above the level of the rails. In districts where brick earth is plentiful, angular or moulded earthen copings are to be used instead of stone, whereby much expense will be saved in the bridge-building department. Over deep and wide cuttings, three-arch bridges may be advantageously introduced.

Where large viaducts are necessary, we recommend that they should be formed on the laminating wood principle, similar to those of the North Shields Railway (see description of these bridges, page 353); the whole of the timbers to be prepared by Bethell's patent process, whereby they are rendered durable, however much exposed to the weather, as the solution is found to penetrate to the very centre of the wood. By the adoption of this system of viaduct-building, a very great expense is necessarily saved. Occupation-arches under the railway are to be 10 feet wide and 12 feet high, and over the railway to be 10 feet in the clear between parapets.

5. LEVEL ROAD-CROSSINGS.—Wherever it is practicable, the crossing of a railway by a road of any kind should be avoided; but where this cannot by any possibility be effected, then a level paved way must be formed (as shewn in Plate 16, fig. 20), with one gate, however, instead of two, 12 feet in length, and furnished with a disc in the middle. A small wooden lodge will also be required, to contain two apartments, one of which is to be furnished with

a fire-place and chimney of brick ; but where brickwork is built at a low rate, as in Ireland, then the lodges may be built of brick, and in stone districts of rough-tooled stonework.

In forming occupation level-crossings, a cattle-arch of 6 feet wide and 7 feet high should also be introduced, as on the Birmingham and Derby, and Northern and Eastern Railways : lodges are of course not required to be built at these crossings. When it is practicable to bring a number of field-gateways on each side into a side occupation-lane formed for the purpose, it is desirable to build a bridge over or under the railway, as the case may be, thereby avoiding several level crossings, besides the additional cattle-arches.

6. PERMANENT WAY.—The gauge of way is proposed to be of 5 feet in new districts ; but if the intended line is to join any other railway, it must of course correspond with the gauge of that line. The rails, chairs, pins, keys, felt-blocks, sleepers, and ballasting, constitute the permanent way, or upper works of railways.

The rails throughout the cuttings and tunnels are to be of the bridge-form, weighing about 56 lbs. to the yard lineal, nearly similar in cross section to fig. 24, Plate 3, and laid with an intermedium of felt on longitudinal timbers of American pine, (bethellized and coated externally with Stockholm tar,) 12 inches on bed by an average thickness of 6 inches, two timbers being cut out of a whole baulk (see fig. 2, Plate 16), so that the rails are fixed with a slight inclination inwards, and secured thereto by screws similar to those used in the permanent way of the Great Western line (see fig. 4, Plate 16). The whole of the screws to be immersed in boiling linseed oil for 48 hours before being used, and the number to each 15-feet rail to be twenty-four. Cross ties of old ship-oak, 8 inches by 4 inches (where it can be obtained at a moderate cost), to be introduced between, and dovetailed into, the longitudinal timbers at intervals of 6 feet, and secured thereto by screw-ties, according to the section fig. 2, Plate 16.

On embankments, shallow parallel rails (see Plate 3, fig. 7), weighing 56 lbs. to the yard, are to be entirely used, to be fixed in chairs, the sockets of which are to correspond in shape with the lower part of the rail, leaving only sufficient space for inch-deal wedges, thus getting rid of large keys or other fastenings altogether. The chairs are to be secured with War-

den's patent spikes to the cross-sleepers; or stout oaken pins or trenails, where the spikes are costly: three spikes or pins to each joint-chair, and two spikes to each intermediate chair. The joint-chairs to weigh 22 lbs., and the intermediate chairs 16 lbs. each respectively. The chairs to be fixed on a level surface of the sleepers; and the lateral inclination given to the rail to be obtained by forming the bottom of the socket with a slope of $\frac{1}{8}$ th of an inch in its width.

The cross-sleepers are to be of larch 9 feet in length, and having a cross section of 10 inches by 5 inches; or sound old ship-oak, if it can be obtained at a moderate cost, and of a scantling something like 9 inches by $4\frac{1}{2}$ inches. The larch-sleepers to be prepared by Bethell's process.

The bearings of rails to decrease in length towards the joints; a plan adopted by Mr. Stephenson on the North Midland and Northern and Eastern Railways. Thus in a 15-foot rail the joint-bearings are to be each 2 feet 9 inches; and the intermediate bearings 3 feet 2 inches each.

The ballasting must depend upon the particular district through which the railway is carried. Small coal and cinders form the best kind of ballasting; broken stone, gravel, indurated sand, burnt shale, burnt clay, or sand, will all answer the purpose. The depth of ballasting throughout to be 18 inches; and when it can be effected (in the absence of cinders or small coal), it will be better to let the sublayer for 12 inches be of broken stone or gravel, and the upper layer of firm sand. The whole width of ballasting throughout the single way is to be 10 feet in width on the top surface, and to be sloped off gradually to the verge of the embankments, or to the verge of the side-drains of cuttings.

At every change of inclination a gradient-indicator is to be fixed up, either of wood or iron (see Plate 16, fig. 36); if of wood, the butt-end is to be charred to 3 inches above the surface of ground. At the top and bottom of planes having inclinations rising more than 1 in 150, these indicators are to be raised to a height of 5 feet above the ground, and a lamp with a strong reflector fixed on the top (Plate 16, fig. 36), to remind the engine-driver of regulating the admission of steam to the cylinders, or the stoker of applying the brake when necessary.

The mile-standards may be either of stone, wood, or iron, according to the particular district; the standards to be double-faced (Plate 16, fig. 35), so

that the figures may be readily seen on approaching them from either side. Where the inclines have second-class gradients, the distance-standards to be fixed at each eighth of a mile, otherwise at intervals each of a quarter of a mile. The faces to be of different forms, to distinguish the mile from the eighth, the quarter, or the half-mile, &c.

7. STATIONS AND DEPÔTS.—In order fully to illustrate this system, we have shewn in Plate 2 a plan of a terminal station (fig. 2), and a plan of an intermediate exchange-station (fig. 3). Although only occupying $3\frac{1}{4}$ acres of ground, the terminal station and depot are sufficiently large for the amount of passenger and merchandise-traffic we have taken as a basis for our calculations throughout; besides which accommodation we have provided a large coal and lime-depôt, with eight commodious cellars under the level of the railway, having openings for shooting the coal or lime from the wagons; each cellar is 47 feet deep, 15 feet wide, and 7 feet high, with three eyes to each. The coal and lime-office is next the high-road, and adjoining the sloped common road leading to the coal-cellars. The secretary's, engineer's, and other offices, are over the booking-office and waiting-rooms. The entrance for first-class passengers is distinct from that for second and third-class passengers; a waiting-room is provided for ladies and another for gentlemen being first-class passengers, and a general waiting-room for second-class passengers.

The merchandise-depôt consists of a large warehouse of three stories, altogether 100 feet long by 50 feet wide, besides cellars, having an available capacity of 70,000 cubic feet. On the level of the railway, at the end next to the common-road wagon-yard, are railway wagon-docks (*fff*) for loading or unloading to or from the common-road wagons. The floors of the warehouses are furnished with trapways for raising or lowering goods to or from the railway-wagons. The offices in this department are contiguous to the large warehouse, and entered from the common-road wagon-yard. A weighing-machine (*h*) is placed on the middle line of way in the warehouse.

The engine-house and carriage-house are conveniently placed contiguous to the station, as will be seen by the plan. The coke-store and water-tank are elevated above the cross line which runs between the offices and the engine-house, so that the coke is easily lowered in sacks, at a moment's notice, by means of a convenient trapway in the floor.

Carriage-docks (*g g*) are conveniently placed for embarking or disembarking gentlemen's carriages on trucks.

The arrival and departure, or up and down lines, are quite apart.

An intermediate exchange-station is shewn in plan in fig. 3; it is supposed to be in cutting. The offices are above, on the level of the high-road or cross-road contiguous. The platforms of the up and down lines are entirely distinct from each other. A separate approach is provided for those going by the up, and those going by the down-train; and there is also a separate departure-passage for those who have arrived by the up-line and those who have arrived by the down-line. Moreover, the entrance to the station is on one side of the cutting, and the exit-gates on the other. A bridge sufficiently removed from the buildings, and over the cutting, effects the necessary communication with the city or town, as the case may be. The requisite conveniences are placed as much as possible out of sight of the passengers in the railway-carriages.

The engine and carriage-sheds are placed on either side of the lines, and between these are two 30-feet turn-tables (for engine and tender) to be moved by rackwork and pinion, similar to that of the Greenwich Railway.

COKE-OVENS.—In almost every district of England and Scotland it is more economical for a company to make their own coke than to purchase it from regular coke-burners. Twenty-four coke-ovens, similar to those of the Newcastle and Carlisle Railway (see page 347), placed, if possible, towards the middle the line, will be sufficient for the quantity of coke required.

MODE OF CARRYING ON THE TRAFFIC.—For the sake of easy illustration, we may suppose a line of railway is to be constructed between two large towns, sixty miles apart, and through a populous district of country; the traffic daily being equal to 380·74 first-class passengers, carried the whole distance; 714·28 second-class passengers, carried the whole distance; and 366·30 third-class passengers, carried the whole distance (the fares per mile for each class respectively being 2·50*d.*, 2·00*d.*, and 1·30*d.*); and the traffic in merchandise being equal to 200 tons of goods daily, also carried the whole distance, the average charge being equal to 3*d.* per ton per mile. To continue

the illustration in an intelligible manner, we may suppose the trains to start simultaneously from either end of the line, and from each intermediate stopping-place, at every hour, or twenty-four trains daily. The number of first-class passengers going in each direction daily will be equal to 190·37; of second-class passengers to 357·14; and of third-class passengers to 183·15; which will give for each train an average number of 7·83 first-class passengers, 14·88 second-class passengers, and 7·63 third-class passengers. The number of passengers, therefore, per train would be 30·34; and the weight of passengers (with luggage), allowing 180 lbs. gross for each, would be equal to 2·438 tons.

The carriages we propose to construct in four compartments; the two middle ones being for first-class passengers, and the end ones for those of the second class. The middle compartments would each hold six persons, and the end compartments each eight passengers, or altogether twenty-eight passengers. These carriages to be mounted on six of Losh's, or other equally approved 3½-feet wrought-iron wheels; and to be hung with Adam's bow-springs, and within 12 inches of the level of the rails (which renders the cost of raising the platforms at the stations to a considerable height unnecessary); the extreme width of each carriage being 7 feet 3 inches, and the whole length of the united bodies 20 feet. The weight of this description of carriage would be about 4·75 tons.

The third-class passengers we propose to convey in four-wheel wagons, furnished with seats. The net weight of such a wagon is about 2·50 tons; so that the average gross weight of passengers and carriages per train would be only 9·68 tons.

The gross weight of each train we propose not to exceed about 26½ tons, or 59,360 lbs. The post-office establishment, weighing in round numbers 10 tons, might be taken by two of the trains daily, and extra bags by every other train, if necessary. The average weight of merchandise, &c. per diem would be 200 tons, or 9·09 tons by each of the twenty-two trains. Two four-wheel wagons, weighing each 2·25 tons, would be necessary to convey the merchandise, so that the ordinary train would consist of two wagons, or trucks, of merchandise, &c. placed next to the engine, then the passenger-wagon, and lastly the passenger-carriage; and the mail-train would consist of the passenger-wagon placed first, then the post-office establishment, and

lastly the mixed passenger-carriage. The average gross weight of the ordinary train would thus be 23·27 tons, and of the mail-train 19·68 tons ; but each ordinary train might take up one gentleman's carriage, and the mail-train two, either from the terminal station, or from any of the intermediate stations ; so that the gross load of the mail-train, with the addition of the gentlemen's carriages, would be 26·18 tons, and of the ordinary train with one such carriage, 26·52 tons.

The speed throughout, including stoppages, may be taken, for example, at twenty miles an hour ; so that the sixty miles would be performed in three hours. We have already said, that we propose the trains to start at every hour in the day from the terminal and principal intermediate stations. It remains only to describe the peculiar system of working the trains by a single line of way.

We will call the terminal stations A and B (see the diagram, Plate 2, fig. 1), and the principal intermediate exchange-stations D and F ; the distances between the terminal and the nearest principal intermediate station, and between the two principal intermediate stations, is twenty miles, which distance is made up of two engine-runs, of equal length, meeting together at the half-way stations C, E, and G. To illustrate the mode of exchanging the trains, which takes place at the exchange-stations C, D, E, F, and G, nearly simultaneously every hour, we need only describe this process between the terminal station A and the first principal intermediate station D (see figs. 1, 2, and 3, Plate 2). An engine (No. 1) starts from station A, and another (No. 2) from station D, as the clock strikes eight. At an average speed of 25 miles an hour, including stoppages, the engines No. 1 and No. 2 will arrive by 24 minutes after eight at the exchange-station C, where each engine-run is furnished with a large turn-table (*z y*) capable of holding the engine and tender together (as adopted by Mr. Miller on the Greenwich Railway). An engine (No. 3) is already on the up-line, ready to proceed with the up-train ; and another (No. 4) on the down-line, ready to proceed with the down-train. The engines Nos. 1 and 2, which have just arrived, are turned into the engine-shed on either side, and the engines Nos. 3 and 4 are connected with the up and down-trains respectively, and proceed forward precisely at 8 h. 30 m., there being six minutes (for the sake of example) allowed for the exchange, for attaching or detaching carriages, &c., and for receiving or

disembarking passengers. At 8 h. 54 m. engine No. 3 will arrive with the up-train at the arrival-platform of the terminal station A, where the passengers and luggage will be despatched by omnibuses, &c., which leave the station by the gateway *c*. The other gateway *d* (the two being separated by a small porter's lodge and fence) is for the arrival of omnibuses, &c.

In the mean time the nine o'clock down-train is preparing to start with engine No. 5, which has its steam up, and is waiting for the nine o'clock bell to be rung, or bugle sounded. The clocks at each station throughout are required to be of uniform construction and by first-rate makers, and regulated twice in the twenty-four hours by means of the electro-galvanic telegraph, which we consider a necessary appendage to all main lines of railway. At 24 minutes past 9, engine No. 5 will arrive with the second down-train at exchange-station C, and engine No. 6 will also arrive within a minute, before or after, with the second up-train at the same station. As on the first exchange, so again engines Nos. 1 and 2 are ready to proceed, on the signal being given, at 9 h. 30 m. with the up and down-trains respectively. Engines Nos. 5 and 6 are turned into the engine-sheds as before, and prepared to make the next exchange. At 9 h. 54 m. engine No. 1 arrives at the terminal station A as before, and engine No. 3 is again ready to start with the ten o'clock train; and so the reciprocating process is continued throughout the twenty-four hours at each of the intermediate exchange-stations.

We have taken intervals of one hour each for the starting of the trains, and also *ten-mile runs*, for the sake of easy illustration; but intervals of 90 minutes, which would give sixteen daily trains, and longer runs, according to each particular case, would answer equally well. We have supposed a very large daily traffic, as will be seen by reference to the number of passengers and tons of merchandise as above, in order to shew that the system is equally well suited for a large as for a small amount of business.

FURNISHING THE LINE.—We now come to the number of engines, carriages, and trucks, &c. necessary for carrying on the above amount of traffic. For this purpose two working engines and tenders, and two spare-engines and tenders, will be required at each terminal station, A and B; six at each of the stations D and E; and two at each of the half-way stations C, E, and G; altogether twenty-six engines of class D, but modified in their proportions

for each run, according to the ruling gradient thereof; each of the six sets of engines to be in every respect uniform.

Of carriages and passenger-wagons there will be required twelve of each sort only, as they go from one terminus to the other.

We have supposed four intermediate minor stations, in addition to the terminal, principal intermediate, and exchange-stations; and we propose to keep two carriage-trucks and two horse-boxes at each of the terminal, at each of the intermediate exchange-stations, and one of each sort at the minor stations respectively; so that altogether there would be eighteen, or with two spare ones, twenty horse-boxes and twenty carriage-trucks respectively.

There would also be required twenty merchandise-wagons, twenty coal and lime-wagons, ten ballast-wagons, and twenty cattle-trucks, distributed about the different stations throughout, according to the peculiar nature of the district traversed.

THE ESTABLISHMENT.—For the effectual working of the reciprocating system, the following would be the number of persons required in the various departments:—One secretary, one superintendent of the locomotives and mechanical department, one general superintendent of the line, two resident engineers and two draftsmen (either two residing at each terminal station), six clerks in the secretary's office, two clerks (one at each terminal station) in the superintendent's department, fourteen booking-clerks in the coaching department, two clerks in the locomotives-department, four clerks in the stores-department, and six clerks in the merchandise-department.

Besides the above, there would be required in the coaching-department, eight guards, twenty-six porters, and twenty-six police at the stations, four at each of the terminal stations, and two at each of the intermediate stations. In the construction-department, twenty overlookers of waymen (who are all to be sworn in as constables, to act in case of need, and also to give the requisite signals), ninety waymen, and ten bricklayers, masons, and carpenters. In the locomotives-department, eighteen engine-drivers and eighteen firemen; twelve coke and water-fillers, and table-turners; twelve fitters, twelve smiths, and twelve strikers. In the coach-building and repairing department, twenty artificers altogether. In the coking department, one foreman, six burners, and six labourers; besides twelve supernumeraries in various departments:

altogether 337 persons. The annual expense on this account, exclusive of wages in the coking-department, would be 21,184*l.*, according to the average of salaries and wages paid throughout the kingdom.

LOCOMOTIVE ENGINES, COKE, &c.—The number of miles run by the locomotive engines per annum would be equal to 1,051,200; the gross load moved one mile per annum, taking 26·50 tons as the average gross load for each train, as before, would be 27,856,800 tons. Taking the consumption of coke as equal to ·715 lb. per ton per mile, which is a full allowance, we have 8899·17 tons. To make this quantity of coke, it would require 13,183·95 tons of the best coking coal, the average cost of which, taken throughout Great Britain, may be set down at 20*s.* a ton. We have already given the number of persons required in the coking department; the amount for wages would be equal to 752*l.*, and for coal 13,183*l.* 19*s.*, together 13,915*l.* 19*s.*, which gives ·119*d.* as the cost of coke per ton per mile.

ESTIMATED COST OF CONSTRUCTION, &c.—We now come to the cost of constructing and furnishing a railway in the most substantial and complete manner (but without extraneous ornament) necessary for carrying out effectively the reciprocating system. We shall take the length of the line at sixty miles, as before, and the prices throughout on a liberal scale:—

Preliminary expenses, and obtaining the Act of Incorporation (very uncertain)	£ 18,000	0	0
Engineering and surveying (for three years, during the time of carrying on the works)	5,600	0	0
Law charges (for three years)	3,000	0	0
Salaries (for three years)	1,500	0	0
Lands and compensations, including valuator's charges (at a fixed sum per acre throughout), viz. 6·06 acres per mile, or 363·60 acres for the main single line of way, at an average cost of 250 <i>l.</i> per acre	90,900	0	0
19·83 acres for sidings, at 250 <i>l.</i> per acre	4·957	10	0
3·25 acres for each of the terminal stations and depôts, containing sufficient space for carrying on the large traffic as taken above, according to the reciprocating system, at 500 <i>l.</i> an acre	3,250	0	0
Carried over	£ 127,207	10	0

Brought over	£ 127,207 10 0
1·33 acres for each of the five exchange-stations, and ·66 acres for each of the four minor stations, altogether 9·29 acres, at 350 <i>l.</i> an acre	3,251 10 0
Fencing and drainage throughout complete, including field-gates, at 600 <i>l.</i> per mile	36,000 0 0
Earthworks, taking an average of 60,000 cubic yards per mile, to be executed in the manner already described, at an average of 15 <i>d.</i> per cubic yard	225,000 0 0
Bridges, taking 2·50 per mile, and at an average cost of only 450 <i>l.</i> (on account of their small size)	67,500 0 0
Culverts, at 2 per mile, average cost at 60 <i>l.</i> each	7,200 0 0
Taking two large wooden viaducts, on the laminating principle, at 10,000 <i>l.</i> each	20,000 0 0
Tunnels, taking one mile of tunnelling at an average of only 40 <i>l.</i> per lineal yard, on account of its small sectional area	70,400 0 0
Level crossings, taking ten paved level road-crossings, including four lodges for high roads, at 50 <i>l.</i> each	500 0 0
Permanent way, 275,098 yards lineal of rails, at 56 lbs. to the yard, equal to 6877·45 tons, at 11 <i>l.</i> per ton	75,651 0 0
105,600 chairs for half the main line, at an average weight of 18 lbs. each, equal to 848·57 tons, at 9 <i>l.</i> 10 <i>s.</i> a ton	8,061 8 2·40
Laying half the length of permanent way with cross-sleepers (for main line) including ballasting, &c., 52,800 yards lineal, at 7 <i>s.</i> 6 <i>d.</i>	19,800 0 0
52,800 larch sleepers, bethellized throughout, at 5 <i>s.</i> 6 <i>d.</i> each	14,580 0 0
84,282 yards lineal (for half the length of main line, and for the additional lengths of sidings throughout, and for stations), laying the way with longitudinal sleepers, cross-ties, ballasting, and screws, &c. complete, at 22 <i>s.</i> per yard	92,710 0 0
Stations and depôts; two principal stations and depôts (according to plan in Plate 2), each at 13,213 <i>l.</i>	£ 26,426 0 0
Five exchange-stations (according to plan in Plate 2), each at 4000 <i>l.</i>	20,000 0 0
Four minor stations, at 1500 <i>l.</i> each	6,000 0 0
Coke-ovens—24 ovens similar to those of the Newcastle and Carlisle Railway, high chimney not required	4,500 0 0
	56,926 0 0
	£ 824,787 8 2·40

Brought over £ 824,787 8 2·40

Estimated Cost of furnishing the Railway and Stations:—

Twenty-six locomotive engines and tenders	£ 39,000	0	0
Twelve mixed carriages	6,000	0	0
Twelve passenger-wagons	720	0	0
Twenty horse-boxes	2,000	0	0
Twenty carriage-trucks	2,600	0	0
Twenty merchandise-wagons	1,200	0	0
Twenty coke, coal, and lime-wagons	1,400	0	0
Twenty cattle-trucks	1,400	0	0
Furnishing the stations with water apparatus, turn-tables, lamp-standards, &c. complete	16,000	0	0
Furnishing the engine-sheds with lathes, tools, and implements	11,000	0	0
Furnishing the various offices	2,000	0	0
Electro-galvanic telegraph	18,000	0	0
		101,320	0 0
		£ 926,107	8 2·40

So that the total cost of constructing the railway in the most complete manner is estimated at 824,787*l.* 8*s.* 2·40*d.*, and of furnishing it at 101,320*l.*, or altogether at the average rate of only 15,435*l.* 2*s.* 5·60*d.* per mile.

We now come to the annual revenue and expenditure accounts: the latter of which is founded on data furnished by the every-day working of the various lines of railway in active operation. The average annual revenue-account would stand thus:—

380·74 first-class passengers carried the whole distance daily, equal to 138,970·10 per annum, at 2·50 <i>d.</i> per mile	£ 86,830	5	0
714·28 second-class passengers, ditto, ditto, at 2 <i>d.</i> per mile	130,356	10	0
366·30 third-class passengers, ditto, ditto, at 1·30 <i>d.</i> per mile	43,452	6	4
Carriage of post-office	7,200	0	0
Taking 900 private carriages and 800 horses, carried the whole distance, per annum	2,550	0	0
Parcels	6,000	0	0
Cattle	1,000	0	0
200 tons of merchandise daily (313 days), carried the whole dis- tance, at an average charge of 3 <i>d.</i> per ton per mile	46,950	0	0
	£ 324,339	1	4

The annual expenses of the establishment, exclusive of the wages of those engaged in the coking department would be . . .				£ 21,946	0	0
The coke				13,915	19	0
Materials for and reinstatements of locomotives stock . . .				13,000	0	0
Ditto, ditto, of carriage stock				4,960	0	0
Repairs to bridges and buildings				4,400	0	0
Permanent-way materials				2,200	0	0
Sundries : advertising, printing, stationery, parcels, postage, &c. .				900	0	0
Direction				1,000	0	0
Rates and taxes				900	0	0
Duty to government, at $\frac{1}{2}$ d. per passenger per mile				16,668	0	0
					79,879	19 0
Fund for depreciation of locomotives and carriage-stock, &c. .				30,000	0	0
Interest on loans, &c., take				6,000	0	0
					£ 115,879	19 0

Thus the disbursements would amount, on an average, to only 35·72l. per cent on the gross revenue.

By looking carefully over the different items of the estimated first cost of a railway to be worked by the reciprocating system, as given above, it will be seen that it is taken throughout as if in a difficult country, and that the most liberal scale of prices has been adopted, in order that exceptions may not be taken to the system on account of a false estimate.

As already observed, the distances of the exchange-stations from each other would depend entirely on the amount of traffic ; and the average speed is taken as for a line with a great proportion of second-class inclines.

We have only to add our strong conviction of the absolute necessity of having a ready mode of communication between the guard or captain of the train and the engine-driver, in case of fire, or other accident. Accidents by collision, however, which are by far the most frequent, would be rendered quite impossible by the reciprocating system.

The signals would be easily given by fixing a small alarum (two or more, with distinct sounds, would be better) in a box attached to the tender ; and by means of a string or wire to the guard's seat on each conveyance, and the intervention of a spring-crank, the sounds would be readily effected.

A P P E N D I X.

T A B L E S

SHewing

The Results of Practical Experiments

AS TO

THE ACTUAL WORKING OF BRITISH RAILWAYS;

MADE IN THE YEARS 1837, 1838, 1839, AND 1840,

But chiefly in the Year 1839.

TABLE A.—ARBROATH AND FORFAR RAILWAY.

Date.	Name or N° of Engine.	Average Pressure in lbs.	N° of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.	Remarks
1839.		lbs.		h. m.		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
Sept. 12	Victoria	45	1	6 3·30 P.M.	Arbroath	59,930	15	59·70	51·45	6	1·37	23·07	10·00	17·49	Rainy.
13	Ditto	45	2	7 4·90 A.M.	Forfar	65,010	15	56·20	50·88	7	0·76	30·00	10·00	17·68	
13	Ditto	42	3	8 36·90 A.M.	Arbroath	65,790	15	61·30	56·20	5	1·02	28·57	10·94	16·01	
13	Ditto	45	4	10 35·50 A.M.	Forfar	49,370	15	58·75	45·25	6	2·25	31·25	8·95	19·88	Rainy.

TABLE B.—BIRMINGHAM AND DERBY JUNCTION RAILWAY.

1839.		lbs.		h. m.		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
Oct. 12	Derwent	55	1	1 34·00 P.M.	Hampton	83,288	38·25	116·00	93·25	8	2·84	..	..	24·61	
13	Derwent	55	2	8 14·84 A.M.	Derby	90,996	38·25	121·36	105·64	7	2·24	37·50	4·03	21·72	
Dec. 5	Derwent	55	3	11 32·70 A.M.	Derby	62,312	23·25	59·02	53·46	3	1·85	37·50	6·04	26·09	{ Slight breeze.
—	Burton	55	4	2 13·40 P.M.	Hampton	50,672	22·75	76·80	67·90	3	2·96	46·87	8·77	20·10	
7	Derwent	55	5	11 41·70 A.M.	Derby	71,944	38·25	114·80	101·11	6	2·28	37·50	8·92	22·69	

TABLE C.—DUNDEE AND ARBROATH RAILWAY.

1839.		lbs.		h. m.		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
Sept. 12	Griffin	..	1	3 53·10 P.M.	Dundee	47,664	12·75	42·70	36·70	4	1·50	35·71	9·37	20·84	
13	Fury	54·33	2	2 7·80 P.M.	Arbroath	47,142	13·50	49·15	42·59	4	1·64	33·33	8·82	19·01	
—	Ditto	54·00	3	3 53·10 P.M.	Dundee	58,080	14·00	46·30	39·52	5	1·35	37·50	9·09	21·25	
14	Rapid	..	4	2 7·80 P.M.	Arbroath	50,144	14·25	43·30	38·33	4	1·24	35·71	10·13	22·30	Rails wet

TABLE D.—GARNKIRK AND GLASGOW RAILWAY.

Date.	Name or N° of Engine.	Average Pressure in lbs.	N° of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.
1839.		lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.
Sept. 3	Garnkirk	..	1	1 32·40 P.M.	Glasgow	15,360	8	34·70	32·83	3	00·62	30·00	5·76	14·62
—	Ditto	..	2	7 00·33 P.M.	Gartsherrie	15,000	8	29·67	27·30	3	00·79	..	..	17·58
4	Ditto	..	3	7 16·56 A.M.	Glasgow	14,640	8	30·44	28·91	2	00·76	24·19	10·00	16·60
—	Ditto	..	4	8 58·00 A.M.	Gartsherrie	24,100	8	32·50	00·14	3	00·78	30·00	7·50	15·92
—	Ditto	..	5	10 16·90 A.M.	Glasgow	19,640	8	27·90	27·90	—	..	30·00	11·53	17·20
—	Ditto	..	6	6 55·95 P.M.	Gartsherrie	19,280	8	29·55	28·95	2	00·30	25·00	5·35	16·58

TABLE E.—GRAND JUNCTION RAILWAY.

Date.	Name of Engine.	lbs.	N° of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.
1839.		lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.
Jan. 15	Eagle	..	1	11 41·00 A.M.	Birmingham	82,544	75·50	226·00	205·80	5	4·05	33·33	13·33	22·01
June 16	Basilisk	..	2	12 29·10 P.M.	Warrington to Birmingham	95,312	76·50	196·15	174·73	5	4·28	37·50	10·71	26·27
July 31	Shark	..	3	5 17·00 P.M.	Birmingham	62,560	76·50	216·75	199·73	5	3·40	33·33	7·50	22·99
Aug. 30	Lynx and Prospero to Wolverhampton, Lynx and Eagle to Whitmore, and Lynx to Warrington	55	4	11 29·75 A.M.	Birmingham	131,532	76·75	207·00	173·34	6	5·61	42·85	4·15	26·56
Oct. 14	Medea	56	5	12 53·30 P.M.	Stafford to Crewe	121,112	24·20	59·30	54·75	1	4·55	56·76	10·79	26·52
—	Vampire	60	6	2 23·50 P.M.	Crewe to Whitmore	77,944	10·45	29·35	29·35	..	..	34·09	15·30	21·36
—	Clio	55	7	3 51·90 P.M.	Whitmore to Warrington	61,504	34·25	73·30	66·46	2	3·42	68·18	10·71	30·92
—	Oberon	57½	8	6 11·20 A.M.	Birmingham to Hartford	74,400	65·00	193·20	152·43	19	2·14	48·38	6·94	25·58
—	Medusa	..	9	9 55·40 A.M.	Hartford to Stafford	95,984	35·75	99·98	87·18	2	6·40	38·46	5·20	24·60
Nov. 13	Hecla	55	10	7 23·10 A.M.	Warrington	61,840	24·00	75·15	64·37	4	2·69	40·54	5·92	22·37
—	Alecto	..	11	10 59·00 A.M.	Crewe to Whitmore	81,872	10·03	27·60	27·60	..	..	34·09	7·55	21·80
—	Lucifer	55	12	1 20·50 P.M.	Whitmore to Crewe	88,928	10·20	16·60	16·60	..	..	68·18	8·92	36·86
—	Medea	50	13	2 22·12 P.M.	Crewe to 92 miles from Liverpool	75,696	48·25	128·36	110·46	3	5·96	37·84	9·43	26·20
14	Oberon	..	14	4 53·60 P.M.	Birmingham	67,584	42·75	96·70	88·50	2	4·07	..	..	28·96
15	Stentor	53	15	9 33·20 A.M.	Warrington	89,272	34·75	103·65	96·95	2	3·35	48·69	8·06	21·50
—	Camilla	57	16	11 23·50 A.M.	Whitmore to Crewe	..	9·14	16·20	16·20	..	..	68·18	10·62	33·85
16	Oberon	57	17	4 32·40 A.M.	Warrington to Birmingham	45,628	77·50	191·90	166·34	5	5·11	39·47	9·25	27·95
—	Sunbeam	55	18	11 29·50 A.M.	Birmingham	78,256	70·50	173·29	148·60	6	4·11	68·18	9·20	28·46

RESULTS OF PRACTICAL EXPERIMENTS.

V

TABLE E.—GRAND JUNCTION RAILWAY—(continued.)

Date.	Name or N° of Engine.	Average Pressure in lbs.	N° of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.	Remarks.
1839. Nov. 16	Sunbeam	lbs. 55	19	^{h.} ^{m.} 2 39·15 P.M.	Warrington to Newton Junction.	lbs. 55,392	Miles. 5	Minutes. 12·85	Minutes. 12·85	..	..	Miles per hour. 34·09	Miles per hour. 10·34	Miles per hour. 23·34	
—	Torch	..	20	4 46·40 P.M.	Newton Junction	60,488	5	14·63	14·03	..	..	..	..	21·38	
—	Torch	..	21	5 7·90 P.M.	Warrington	79,328	77·50	242·10	194·83	20	2·36	..	..	23·86	
18	Basilisk	56	22	2 56·00 P.M.	Birmingham	83,044	77·50	188·00	171·41	5	3·31	..	..	27·12	
19	Lynx	55	23	8 48·68 A.M.	Newton Junction	63,144	5	10·20	10·20	..	..	35·71	21·42	29·41	
—	Lucifer	55	24	10 14·62 A.M.	Warrington	58,360	5	10·36	10·36	..	..	41·66	13·88	28·95	

TABLE F.—GREAT WESTERN RAILWAY.

Date.	Name of Engine.	lbs.	N° of Experiments.	Time of Starting.	From whence.	lbs.	Miles.	Minutes.	Minutes.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.	Remarks.
1838. June 4	Æolus	..	1	^{h.} ^{m.} 9 17·75 A.M.	London . .	80,078	22·50	162·75	86·75	2	0·38	..	..	15·56	
—	....	..	2	12 40·00 P.M.	Maidenhead	74,678	22·50	62·00	54·25	3	2·58	..	..	24·88	
July 21	Æolus	..	3	12 10·50 P.M.	London . .	96,194	22·50	150·00	115·25	4	8·68	24·00	4·90	11·71	
—	{Æolus, Lion, as far as West Drayton}	..	4	5 14·00 P.M.	Maidenhead	80,266	22·50	65·50	59·00	2	3·25	30·00	14·11	22·88	
Nov. 6	Æolus	..	5	2 00·00 P.M.	London . .	44,440	22·50	45·50	43·00	2	1·25	48·00	15·00	31·39	
—	Venus	..	6	4 1·50 P.M.	Maidenhead	57,524	22·50	67·75	64·00	2	1·87	34·28	6·66	21·09	
1839. July 20	Atlas	..	7	12 3·00 P.M.	London . .	106,944	30·75	90·80	82·33	4	2·11	33·33	4·68	22·40	
—	{Ajax Neptune}	..	8	2 00·00 P.M.	Twyford .	85,760	30·75	72·00	66·29	3	1·90	50·00	6·35	27·83	
Aug. 8	Lion	..	9	1 52·75 P.M.	London . .	97,706	18·25	49·05	48·07	1	0·98	41·66	7·91	22·77	{Strong head wind.
—	Evening Star	..	10	2 35·80 P.M.	Slough . .	133,079	18·25	42·95	42·25	1	0·70	42·85	8·67	25·91	
9	Evening Star	..	11	11 59·10 A.M.	London . .	95,512	18·25	41·70	39·36	1	2·34	44·11	8·92	27·82	
—	Atlas	..	12	4 33·50 P.M.	Slough . .	99,354	16·50	33·09	33·09	..	..	42·85	9·43	29·91	
12	Vulcan	..	13	1 28·60 P.M.	London . .	39,698	13·00	30·40	27·54	3	0·95	50·00	9·20	28·32	
—	Vulcan	..	14	2 57·00 P.M.	W. Drayton	31,356	13·00	40·60	36·97	4	0·90	50·00	5·35	21·09	
14	Morning Star	..	15	12 0·25 P.M.	London . .	107,698	18·25	47·75	45·75	1	2·00	39·47	10·00	23·93	
—	Atlas	..	16	4 36·95 P.M.	Slough . .	104,464	18·25	41·66	41·66	..	..	37·50	11·02	26·28	{Rails wet. Clear weather
Dec. 13	Evening Star	52	17	8 58·70 A.M.	London . .	95,022	30·75	69·65	65·53	2	2·06	44·11	4·28	28·15	
—	Evening Star	52	18	11 57·40 A.M.	Twyford .	90,450	30·75	73·10	66·22	4	1·72	43·38	7·97	27·86	{Slight breeze.
—	Bacchus	50	19	1 26·30 P.M.	London . .	31,356	13·00	31·90	26·83	3	1·69	44·11	11·81	29·07	
—	....	..	20	2 28·70 P.M.	{W. Drayton to Twyford}	76,482	17·50	43·19	37·54	2	2·82	50·00	9·20	27·97	
—	Planet	55	21	3 57·50 P.M.	Twyford .	78,154	30·75	82·50	72·28	3	3·40	35·71	5·45	25·52	
1840. Jan. 9	Bacchus	55	22	1 32·80 P.M.	London . .	32,256	13·00	32·45	30·04	3	0·80	50·00	4·61	25·96	
—	Bacchus	55	23	3 1·40 P.M.	{W. Drayton to London}	33,516	13·00	31·80	29·87	2	0·96	50·00	10·34	26·11	
Mar. 7	Eagle	..	24	12 6·12 P.M.	London . .	69,426	30·75	65·00	60·02	3	1·66	45·45	5·49	30·73	
—	North Star	..	25	2 6·60 P.M.	Twyford .	67,240	30·75	61·90	57·92	3	1·32	46·87	8·42	31·85	

RESULTS OF PRACTICAL EXPERIMENTS.

TABLE G.—LEEDS AND SELBY RAILWAY.

Date.	Name or N° of Engine.	Average Pressure in lbs.	N° of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.	Remarks.
1839. Aug. 3	....	lbs. 50	1	h. m. 10 10·16 A.M.	Leeds to York Junction	lbs. 40,912	Miles. 13·00	Minutes. 45·17	Minutes. 40·77	3	Minutes. 1·46	Miles per hour. 37·50	Miles per hour. 6·43	Miles per hour. 19·13	
3	Hawke ..	50	2	1 11·50 P.M.	York Junct ⁿ	75,120	13·50	45·35	43·40	2	0·97	37·50	7·02	18·66	
Oct. 26	Dart	50	3	4 22·70 P.M.	Ditto ...	90,780	13·50	49·02	46·02	3	1·00	37·50	3·97	17·60	
—	Ditto ....	..	4	7 3·30 P.M.	Leeds ...	58,456	13·50	44·70	40·32	3	1·46	..	..	20·00	
27	Express ..	50	5	9 10·40 A.M.	York Junct ⁿ to Selby	47,424	6·50	18·60	17·62	1	0·98	30·00	4·32	22·13	
29	Lord Hood	50	6	12 17·80 P.M.	Selby ...	43,370	6·25	16·16	16·16	..	..	30·00	12·50	23·20	
—	Express ..	50	7	6 19·25 P.M.	York Junct ⁿ	52,800	13·50	40·75	40·13	2	0·31	..	..	20·18	
31	Dart	50	8	10 7·30 A.M.	Leeds to Milford	59,128	12·00	31·55	30·55	2	0·50	37·50	10·71	23·56	
31	Swallow .	45	9	10 51·80 A.M.	Milford to Leeds	73,360	12·00	32·82	30·78	2	1·02	38·46	9·55	23·39	
31	Express ..	50	10	12 20·10 P.M.	Leeds ...	37,436	13·50	31·38	31·38	..	..	35·71	8·87	25·81	
31	Ditto ...	50	11	12 57·10 P.M.	York Junct ⁿ to Selby	97,664	6·00	20·10	20·10	..	..	26·31	7·50	17·91	Strong head wind
31	Dart	50	12	3 25·35 P.M.	Selby ...	59,168	20·00	57·65	50·70	4	1·73	44·11	9·20	23·66	
31	Ditto ...	50	13	5 59·70 P.M.	Leeds ...	58,456	13·50	40·30	40·30	..	..	..	..	20·09	

TABLE H.—LIVERPOOL AND MANCHESTER RAILWAY.

Date.	Name or N° of Engine.	Average Pressure in lbs.	N° of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.	Remarks.
1839. Jun. 16	Zaniel (G. J. R.)	lbs. ..	1	h. m. 11 30·90 A.M.	Manchester	42,040	15·75	34·10	34·10	..	..	32·08	25·00	27·71	
Aug. 1	Ætna ...	..	2	5 18·00 P.M.	Manchester	82,579	14·00	35·75	35·15	1	0·60	37·50	9·80	23·89	
3	....	..	3	7 19·50 P.M.	Manchester	50,918	16·00	36·60	30·35	1	6·25	..	..	29·75	
30	Lynx (G. J. R.)	..	4	3 18·50 P.M.	Warrington Junction to Liverpool	70,630	13·00	30·00	..	..	..	37·50	16·16	26·00	
Nov. 9	Milo ....	..	5	7 24·40 P.M.	Manchester	87,657	30·75	87·20	83·50	3	1·26	..	..	22·09	
11	....	..	6	8 52·40 A.M.	Liverpool .	50,563	14·25	29·48	27·98	1	1·50	50·00	16·30	30·55	
—	Rokeby ..	..	7	9 48·80 A.M.	Newton to Liverpool	79,057	14·25	41·30	41·30	..	..	46·87	5·76	20·70	
—	Arrow ...	..	8	11 13·80 A.M.	Edge Hill .	60,510	14·25	30·10	30·10	..	..	34·88	15·00	28·40	
—	Vesuvius .	..	9	12 39·80 P.M.	Newton to Liverpool	52,484	13·75	48·40	41·66	7	0·96	33·33	8·62	19·80	
—	Roderic ..	..	10	2 3·00 P.M.	Liverpool .	53,198	14·25	32·10	30·36	1	1·74	44·11	10·71	28·16	
—	Arrow ...	..	11	3 45·80 P.M.	Newton to Liverpool	78,975	14·25	52·00	43·01	7	1·28	40·54	8·82	19·87	
Nov. 16	Oberon (G. J. R.)	..	12	3 44·30 A.M.	Edge Hill to Warrington Junction	15,302	13·00	26·80	26·80	..	..	..	..	29·10	
—	Sunbeam (G. J. R.)	..	13	2 52·00 P.M.	Warrington Junction to Edge Hill	54,882	13·00	32·26	31·11	1	1·15	37·50	10·63	25·07	

TABLE H.—LIVERPOOL AND MANCHESTER RAILWAY—(continued.)

Date.	Name or N° of Engine.	Average Pressure in lbs.	N° of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.	Remarks.
1839.		lbs.		h. m.		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
Nov. 16	Torch (G. J. R.)	..	14	4 10·80 P.M.	Edge Hill.	58,154	13·00	34·40	31·93	5	0·49	46·87	7·89	24·42	
19	Lynx . . .	55	15	8 22·75 A.M.	Edge Hill.	41,374	13·00	24·92	24·92	..	..	46·87	15·00	31·30	
—	Lucifer ..	55	16	10 25·20 A.M.	Warrington Junction to Edge Hill	56,032	12·75	28·65	28·65	..	..	37·50	11·27	26·70	Head wind.
25	Rokeby ..	56	17	10 17·75 A.M.	Edge Hill.	34,297	29·25	100·88	85·70	16	0·94	42·85	10·94	20·47	
—	Comet . . .	..	18	5 3·50 P.M.	Manchester	68,025	29·25	70·80	68·47	2	1·16	..	..	25·63	
26	Sun . . . .	..	19	7 20·75 A.M.	Edge Hill to Kenyon	52,844	17·25	54·35	47·33	8	0·87	44·11	9·37	21·86	Rails wet.
—	Arrow, Mammoth assisting at Incline ..	55	20	3 27·50 P.M.	Kenyon to Edge Hill	76,991	17·25	71·50	60·67	5	2·16	30·60	7·50	17·05	
27	Roderic ..	59	21	8 56·00 A.M.	Edge Hill.	63,313	14·25	38·60	38·60	..	..	34·09	4·32	22·15	Head wind.
—	Mastodon.	52½	22	2 42·00 P.M.	Newton to top of Sutton Incline	44,800	5·50	19·33	19·33	..	..	27·77	6·81	17·07	
—	Roderic ..	58	23	3 12·35 P.M.	From top of Sutton to St. Helen's Junction	59,999	1·75	3·90	3·90	..	..	31·25	18·75	26·92	
—	Roderic ..	..	24	6 25·50 P.M.	St. Helen's Junction	32,757	10·25	31·00	29·18	3	0·60	..	..	21·07	
28	.....	..	25	9 6·30 A.M.	Edge Hill to Newton	64,213	14·25	33·12	33·12	..	..	35·71	18·51	25·81	
—	Rokeby ..	..	26	11 9·08 A.M.	Warrington Junc ⁿ to N. Union Junc ⁿ	34,297	1·75	11·12	6·24	2	2·44	35·71	7·00	16·82	
—	Arrow . . .	..	27	3 45·80 P.M.	N. Union Junction to Edge Hill	41,909	15·00	49·37	41·65	6	1·28	32·60	11·53	21·60	Rails greasy.
Dec. 2	Panther ..	..	28	11 53·40 A.M.	Liverpool	41,812	29·25	98·40	86·27	12	0·92	40·54	6·04	20·34	

TABLE I.—LONDON AND BIRMINGHAM RAILWAY.

Date.	Name or N° of Engine.	lbs.		h. m.		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
1837.															
July 20	Bury's Engine	..	1	9 57·25 A.M.	London to Boxmoor	72,312	23·50	97·25	75·75	3	7·16	26·66	12·00	18·61	
26	Ditto ..	..	2	10 00·75 A.M.	London ..	137,968	11·25	45·25	40·25	2	2·50	24·00	12·63	16·79	
—	Ditto ..	..	2 a	2 38·00 P.M.	Harrow to London	109,168	11·00	34·50	28·00	1	6·50	30·00	16·00	23·57	
Aug. 25	Ditto ..	..	2 b	5 1·75 P.M.	London ..	105,568	11·00	36·00	31·75	2	2·12	..	..	20·78	
Oct. 17	Ditto ..	..	3	10 8·50 A.M.	London ..	119,176	31·75	107·50	88·00	5	3·90	..	..	21·68	
1838.															
May 18	Ditto ..	..	4	11 8·00 A.M.	Camden Dépôt	85,648	46·75	137·50	113·75	6	3·95	30·00	2·50	24·65	
—	Ditto ..	..	5	3 37·00 P.M.	Denbigh Hall to London	149,840	47·75	136·50	124·75	3	3·91	40·00	8·57	22·96	

RESULTS OF PRACTICAL EXPERIMENTS.

TABLE I.—LONDON AND BIRMINGHAM RAILWAY—(continued.)

Name or N° of Engine.	Average Pressure in lbs.	N° of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.	Remarks.
	lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
{ Bury's Engine	. .	6	9 7.50 A.M.	London . .	55,296	112.00	361.10	278.73	16	5.14	37.50	13.57	24.10	
{ Ditto . .	. .	7	8 30.00 A.M.	Birmingham	49,328	112.25	312.10	249.98	10	6.21	37.50	16.21	26.94	
{ Two of Bury's Engines	. .	8	9 37.50 A.M.	London . .	144,832	112.25	330.50	286.90	8	5.45	33.33	13.48	23.47	
{ One ditto	. .	9	4 11.00 P.M.	Birmingham	68,424	112.25	313.00	274.68	9	4.25	35.29	11.53	24.48	
{ One ditto	. .	10	11 15.66 A.M.	{ Camden Depôt	{ 120,088	111.00	321.34	275.01	10	4.63	35.08	6.81	24.21	
{ Two ditto	. .	11	5 30.50 P.M.	Birmingham	139,276	60.00	165.90	136.48	9	3.26	46.15	8.33	26.37	
{ Twoditto, to Tring only	. .	12	8 3.15 A.M.	{ Camden Depôt	{ 153,300	35.25	108.35	95.50	5	2.57	33.33	7.50	22.14	
{ No. 23 . .	. .	13	4 5.50 P.M.	{ Aylesbury Junction	{ 128,884	15.75	43.00	39.70	2	1.65	37.50	5.11	23.80	
{ No. 72 . .	. .	14	12 36.66 P.M.	Coventry .	60,160	18.00	41.10	38.50	1	2.60	42.85	17.34	28.05	
{ No. 34 . .	. .	15	6 2.60 A.M.	Birmingham	61,152	112.25	341.90	284.18	18	3.20	42.85	8.15	23.69	
{ No. 75, from Wolverton	50	16	8 54.80 A.M.	London . .	83,924	103.00	252.35	230.73	7	3.08	50.00	7.89	26.78	Headw at start
{ Trent, B and D	55	17	10 23.08 A.M.	{ Hampton to Birmingham	{ 98,708	9.25	19.00	19.00	. .	. .	37.50	12.19	29.21	
{ No. 33 to Wol- verton, No. 16 to London	. .	18	5 00.00 P.M.	Birmingham	47,120	111.13	313.12	255.77	16	3.58	. .	. .	26.06	
{ No. 11 to Wolverton	. .	19	11 00.35 A.M.	{ Camden Depôt	{ 79,032	110.75	296.25	265.60	9	3.40	41.09	9.23	25.01	
{ No. 61 to Wol- verton, No. 15 to London	. .	20	12 5.30 A.M.	Birmingham	90,328	112.13	300.20	273.95	6	4.56	. .	. .	24.56	
{ Nos. 4 & 17 to Watford	. .	21	9 37.70 A.M.	London . .	116,604	17.50	46.30	45.22	1	1.08	33.33	18.18	23.22	
{ Nos. 7 & 12	. .	22	2 2.30 P.M.	{ Hampton to London	{ 90,160	102.00	304.20	266.47	7	5.39	35.71	7.38	22.96	
{ No. 39 . .	. .	23	9 31.70 A.M.	London . .	96,788	31.50	79.26	73.80	3	1.82	46.87	10.41	25.60	
{ No. 18 . .	. .	24	1 46.80 P.M.	{ Tring to Wolverton	{ 107,736	20.00	44.09	41.44	1	2.65	41.66	12.29	28.95	
{ No. 64 . .	. .	25	8 10.78 A.M.	London . .	68,464	17.50	47.70	43.63	4	1.017	34.09	8.02	24.06	
{ No. 76 to Wol- verton, No. 19 to Coventry	50	26	9 45.24 A.M.	{ Watford to Coventry	{ 59,860	75.75	185.76	163.36	5	4.48	40.54	5.26	27.82	
{ No. 26 . .	. .	27	1 2.70 P.M.	{ Coventry to Rugby	{ 73,440	10.50	24.82	23.22	1	1.60	38.46	8.57	27.13	
{ No. 36 . .	. .	28	3 41.58 P.M.	{ Rugby to Birmingham	{ 105,364	29.00	74.87	63.37	3	3.83	37.50	11.45	27.45	
{ No. 39 to Wolverton	45	29	9 31.70 A.M.	London . .	83,672	112.25	294.20	243.16	10	5.10	. .	. .	27.69	
{ No. 70 to Wol- verton, No. 3 to London	45	30	6 14.30 P.M.	Birmingham	50,192	111.25	275.70	242.97	11	2.97	. .	. .	27.53	

TABLE K.—LONDON AND CROYDON RAILWAY.

Date.	Name or N° of Engine.	Average Pressure in lbs.	N° of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N° of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.	Remarks.
1839.		lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
May 21	.....	..	1	4 14.75 P.M.	London ..	44,960	10.37	40.25	33.30	5	1.39	27.27	15.00	18.68	
—	.....	..	2	5 15.40 P.M.	Croydon ..	48,972	10.37	32.10	29.60	4	0.62	37.50	10.34	21.02	
July 16	No. 5 ...	..	3	12 19.10 P.M.	London ..	44,960	10.00	36.38	32.42	5	0.79	28.03	11.53	18.50	
—	Archimedes	..	4	2 20.60 P.M.	Croydon ..	41,360	8.00	26.40	24.29	4	0.52	30.00	12.00	19.76	
18	New Engine	..	5	12 15.60 P.M.	London ..	44,060	10.25	37.90	34.19	5	0.74	28.84	7.89	17.98	
—	Surrey ...	..	6	2 15.12 P.M.	Croydon ..	42,080	10.37	27.64	25.85	4	0.44	50.00	7.97	24.10	
24	Kent ....	..	7	2 20.00 P.M.	London ..	41,360	10.37	36.90	33.40	5	0.70	37.50	4.16	18.62	
—	Sussex ...	..	8	3 20.00 P.M.	Croydon ..	40,640	10.37	24.20	22.53	2	0.83	42.85	7.89	27.61	
Dec. ...	Surrey ...	..	9	10 11.70 A.M.	London ..	53,472	8.50	26.16	24.57	4	0.39	32.60	6.81	20.75	

TABLE L.—LONDON AND SOUTH-WESTERN RAILWAY.

		lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
1838.															
May 21	.....	..	1	10 9.50 A.M.	London ..	103,376	22.00	100.00	90.25	6	1.62	21.81	6.66	14.62	
—	.....	..	2	1 3.00 P.M.	Woking ..	96,320	22.00	65.00	57.50	5	1.50	40.00	12.63	22.95	
Nov. 10	Tiger ...	..	3	10 56.50 A.M.	London ..	27,856	17.00	47.50	41.50	5	1.20	34.28	13.33	24.57	
16	.....	..	4	2 55.20 P.M.	London ..	90,000	38.00	107.80	100.22	2	3.79	30.00	9.09	22.75	
1839.															
April 8	Sam Slick	..	5	11 58.90 A.M.	London ..	58,096	15.00	43.10	38.35	4	1.18	36.36	15.38	23.46	
—	Jupiter and Thetis	..	6	12 5.10 P.M.	London ..	92,860	38.00	127.00	97.05	9	3.32	37.50	8.99	23.49	Head wind.
—	Jupiter ..	..	7	4 2.50 P.M.	Basingstoke	96,132	38.00	89.25	71.73	4	4.38	40.00	17.64	31.78	
Aug. 22	Sam Slick and Chaplin from Woking to Farnborough	..	8	12 15.45 P.M.	London ..	109,136	38.00	127.55	103.34	10	2.63	33.51	12.24	22.06	Strong side-wind.
23	Locke ...	..	9	2 47.90 P.M.	Winchester to Southampton	71,160	10.50	28.33	26.73	2	0.80	31.57	8.21	23.56	
—	Ditto ...	..	10	4 6.75 P.M.	Southampton	79,004	9.00	26.42	26.14	1	0.28	31.25	10.81	20.65	
—	Renown ..	..	11	7 33.00 P.M.	Winchfield	103,596	38.00	104.66	92.41	6	2.37	50.00	10.16	24.67	

TABLE M.—NEWCASTLE AND CARLISLE RAILWAY.

		lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
1839.															
Sept. 21	Nelson ..	48½	1	5 17.33 P.M.	Blaydon to Edenbridge	58,563	24.00	65.67	61.44	4	1.05	37.50	5.70	23.43	
—	Ditto ...	..	2	7 9.00 P.M.	18½ miles from Carlisle	57,556	16.75	44.00	34.33	3	3.22	..	..	29.27	
22	Wellington	50	3	4 32.60 P.M.	Carlisle ..	68,404	19.50	59.30	50.58	6	1.45	37.50	9.37	23.13	
—	Ditto ...	..	3 a	6 12.00 P.M.	Haydon Bridge to Blaydon	86,708	24.00	77.00	60.30	8	2.08	39.47	18.75	23.88	
Oct. 15	Goliath ..	43	4	11 33.35 A.M.	Carlisle ..	93,184	9.75	67.68	38.73	1	28.95	22.38	11.53	15.10	
—	Cumberland	50	5	3 15.90 P.M.	Greenhead to Carlisle	56,196	18.25	56.65	48.36	5	1.65	35.71	8.57	22.64	
—	Ditto ...	50	6	1 46.18 P.M.	Milton to Greenhead	55,804	8.50	25.73	23.43	2	1.15	31.91	11.45	21.76	

RESULTS OF PRACTICAL EXPERIMENTS.

TABLE M.—NEWCASTLE AND CARLISLE RAILWAY—(continued.)

Date.	Name or N ^o of Engine.	Average Pressure in lbs.	N ^o of Experiments.	Time of Starting.	From whence.	Gross weight of Trains in lbs. avoirdupois.	Distance travelled.	Total Time occupied.	Time in motion.	N ^o of Stoppages.	Average of Stoppages.	Highest Velocity.	Lowest Velocity.	Average Velocity.	
1839.		lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
Oct. 17	Cumberland	50	7	3 10·43 P.M.	21 miles from Carlisle	44,740	9·25	29·77	24·73	2	3·66	42·85	14·70	24·73	Str he wi
—	Ditto . . .	50	7 a	3 10·43 P.M.	Ditto . . .	44,740	19·00	66·87	54·94	3	3·97	42·85	9·98	20·74	
—	Wellington	50	8	5 5·37 P.M.	Carlisle . .	41,300	13·00	32·23	30·85	2	0·69	41·66	9·49	25·28	
18	Nelson . .	48	9	9 8·65 A.M.	Carlisle . .	54,572	19·50	58·68	49·43	4	2·31	33·33	11·02	23·67	
—	Wellington	50	10	11 14·09 A.M.	Greenhead to Carlisle	41,300	19·50	43·11	39·01	3	1·36	41·66	7·14	29·99	

TABLE N.—NORTH UNION RAILWAY.

1839.		lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
Jan. 15	. . . .	. .	1	4 34·00 P.M.	Parkside .	43,880	22·00	71·00	58·00	5	2·60	. .	. .	22·75	
Aug. 1	No. 5 . .	. .	2	6 4·00 P.M.	Ditto . . .	54,012	22·25	66·50	57·88	7	1·23	34·88	10·00	23·06	
Nov. 20	No. 4 . .	. .	3	2 29·60 P.M.	Preston . .	53,472	22·25	63·00	55·46	7	1·07	40·54	6·60	24·07	
—	No. 4 . .	. .	4	3 52·40 P.M.	Parkside .	43,160	17·50	44·58	41·56	4	0·75	42·85	11·11	25·26	
22	No. 3 . .	. .	5	6 34·60 P.M.	Preston . .	46,380	22·00	51·90	45·10	2	3·40	. .	. .	29·26	
28	No. 4 . .	52½	6	12 3·00 P.M.	Parkside .	22,424	2·50	5·40	5·40	. .	. .	32·60	21·42	27·77	
—	No. 6 . .	50	7	3 16·50 P.M.	{ Wigan to } Parkside }	55,800	6·25	12·00	12·00	. .	. .	37·50	23·43	31·25	

TABLE O.—STOCKTON AND DARLINGTON RAILWAY.

1839.		lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
Oct. 25	Arrow . .	50	1	12 24·50 P.M.	{ Stockton to } Darlington }	39,180	11·25	31·00	29·60	2	0·70	34·09	7·14	22·80	Stron wind. wet.
Sept. 25	Sunbeam .	50	2	7 52·00 A.M.	Stockton .	46,236	11·25	42·50	40·85	2	0·82	30·00	6·38	16·52	
—	Arrow . .	50	3	12 57·50 P.M.	{ Darlington } to Shildon }	18,392	7·25	20·40	18·73	2	0·83	33·33	7·84	23·22	Stron side-
—	Ditto . .	50	4	5 27·00 P.M.	{ Shildon to } 1 mile from } Stockton }	17,496	18·50	51·50	43·83	4	1·91	42·85	4·28	25·32	
26	Ditto . .	50	5	7 47·00 A.M.	{ Stockton to } Darlington }	37,832	11·25	32·00	29·85	2	1·07	37·50	11·11	22·61	
—	Ditto . .	50	6	1 56·75 P.M.	{ Darlington } to Stockton }	37,832	11·25	29·80	28·28	2	0·76	37·50	10·13	23·86	

TABLE P.—YORK AND NORTH MIDLAND RAILWAY.

1839.		lbs.		^{h.} ^{m.}		lbs.	Miles.	Minutes.	Minutes.		Minutes.	Miles per hour.	Miles per hour.	Miles per hour.	
Aug. 3	Lowther . .	. .	1	11 8·05 A.M.	Leeds Junc ⁿ	28,256	14·00	39·95	34·60	4	1·33	. .	. .	24·27	
Oct. 26	York & Leeds	. .	2	3 32·33 P.M.	York	82,836	14·00	46·12	41·82	4	1·07	34·09	6·65	20·08	
—	Lowther . .	. .	3	7 54·00 P.M.	Leeds Junc ⁿ	60,256	14·00	37·60	35·60	2	1·00	. .	. .	23·59	
27	York & Leeds	. .	4	7 36·00 A.M.	York	62,526	14·00	41·20	38·07	2	1·56	32·60	6·45	22·06	
29	Ditto . . .	. .	5	12 58·00 P.M.	Leeds Junc ⁿ	33,856	14·00	37·70	35·50	2	1·10	35·71	15·46	23·66	
—	Ditto . . .	. .	6	5 32·50 P.M.	York	38,344	14·00	40·90	39·10	2	0·90	. .	. .	21·48	Rail

Maker's Name.	N° of Engine.	WHEELS.			WEIGHT OF ENGINE.	
		Nar' of Engt. feet.	Carrying.		In Working Trim.	Empty.
			N°.	Diameter in Feet.		
		ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
R. & W. Hawthorn	Tame . . 6	4	3 6	11 15 0	10 10 0
R. & W. Hawthorn	Blythe . 6	4	3 6	11 15 0	10 10 0
R. & W. Hawthorn	Anker . . 6	4	3 6	11 15 0	10 10 0
Mather, Dixon, & Co.	Barton . 6	4	3 6		-
Mather, Dixon, & Co.	Tamworth 6	4	3 6		
Mather, Dixon, & Co.	Hampton 6	4	3 6		
Tayleur & Co.	Derby . . 6	4	3 6		
Tayleur & Co.	Birmingham 6	4	3 6		
Tayleur & Co.	Burton . 6	4	3 6		
Sharp, Roberts, & Co.	Derwent . 6	4	3 6	....	12 0 0
Sharp, Roberts, & Co.	Dove . . 6	4	3 6	....	12 0 0
Sharp, Roberts, & Co.	Trent . . 6	4	3 6	....	12 0 0

		ns.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
T. Hackworth . . . . .	..	Sanspariel 0	2	4 0		
R. Stephenson & Co. . .	..	Nelson . 0	2	3 0	10 0 0	
Edward Bury . . . . .	..	Bee . . . 8	2	4 8		
Rothwell & Hick . . . .	..	Union . . 0	2	3 0		
W. Dean . . . . .	..	Salamand 8	2	4 8	10 0 0	
W. Dean . . . . .	..	Veteran 0	2	5 0		
Edward Bury . . . . .	..	Clarence 0	4 {	5 0 2 6		
Hargreaves . . . . .	..	Utilis . . 8	6 {	4 8 2 6 1 8	15 6 0	
Hargreaves . . . . .	..	Victoria 8	4 {	4 8 2 6	14 8 0	
Tayleur & Co. . . . .	..	Wellington 6	4 {	5 6 3 6		
Tayleur & Co. . . . .	..	Marquis 6	4 {	5 6 3 6		
Tayleur & Co. . . . .	..	Pandora 6	4 {	5 6 3 6		
B. Hick . . . . .	..	Soho . . 8	4 {	5 8 3 6		
Hargreaves . . . . .	..	Castle . 6	4 {	4 6 3 0	14 16 0	

4 ENGINES.

FUNCTION RAILWAY.

Heated Air.	DIMENSIONS OF FIRE-BOX.				DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
	Length.	Width.	Height above the Grate Bars.	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Of Steam Passage.	Of Blast Pipe.	Driving.		Carrying.		In Working Trim.	Empty.
									No.	Diameter in Feet.	No.	Diameter in Feet.		
t.	inchs.	inchs.	inchs.	sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
	..	..	..	..	..	..	..	..	2	5 0	4	3 6		
	..	..	..	..	..	..	..	..	2	5 6	4	3 6		
	..	..	..	..	..	..	..	..	2	4 6	4	4 6		
	..	..	..	..	..	..	..	..	2	4 0	4	4 0		
10	36	41½	44	54·03	13	..	..	..	2	5 0	4	{5 0 4 0}	13 5 0	12 0 0
10	36	41½	44	54·03	13	..	..	..	2	5 0	4	{5 0 4 0}	13 5 0	12 0 0
10	36	41½	44	54·03	13	..	..	..	2	4 0	4	4 0	13 5 0	12 0 0
10	36	41½	44	54·03	13	..	..	..	2	4 0	4	4 0	13 5 0	12 0 0
10	36	41½	44	54·03	13	..	..	..	2	4 6	4	{4 6 3 6}	13 5 0	12 0 0
10	36	41½	44	54·03	13	..	..	..	2	4 6	4	{4 6 3 6}	13 5 0	12 0 0

D GLASGOW RAILWAY.

st.	inchs.	inchs.	inchs.	sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
17	21½	41	..	..	13	..	..	..	2	4 0	2	4 0	.... nearly	8 0 0
	21½	41	..	..	13	..	..	..	2	4 0	2	4 0	....	9 0 0
	21½	41	..	..	13	..	..	..	2	4 0	2	4 0	....	8 10 0
	..	..	..	..	..	..	..	..	2	4 0	2	4 0	....	10 0 0
	..	..	..	..	..	..	..	..	2	4 0	4	4 0	....	13 0 0
	..	..	..	..	..	..	..	..	..	..	..	..	11 8 2	9 9 0

SLEY, AND GREENOCK.

st.	inchs.	inchs.	inchs.	sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
13	30	41½	48	53·48	..	..	..	..	2	5 0	2	3 6		
	30	41½	48	—	..	..	..	..	2	5 0	2	3 6		
	30	41½	48	—	..	..	..	..	2	5 0	2	3 6		
	30	41½	48	—	..	..	..	..	2	5 0	2	3 6		
11	32	42	46	56·36	13	5 6	12·00	5·93	2	5 0	2	3 6	....	12 10 0
	32	42	46	—	13	5 6	12·00	5·93	2	5 0	2	3 6	....	12 10 0
	32	42	46	—	13	5 6	12·00	5·93	2	5 0	2	3 6	....	12 10 0

M	SIZE.		WHEELS.				WEIGHT OF ENGINE.	
	<i>Of Steam Passage.</i>	<i>Of Blast Pipe.</i>	<i>Driving.</i>		<i>Carrying.</i>		In Working Trim.	Empty.
	Sectional Area in Inches.	Sectional Area in Inches.	N ^o .	Diameter in Feet.	N ^o .	Diameter in Feet.		
				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
Rt. St	8.76	. .	2	5 0	4	3 6	9 12 0	
Haigh	13.75	. .	2	5 0	4	3 6		
Rt. St	. .	. .	2	5 0	4	3 6	9 12 0	
Haigh	13.75	. .	2	5 0	4	3 6		
Haigh	13.75	. .	2	5 0	4	3 6		
Rothv	10.62	5.93	2	5 0	4	3 6	. . . .	11 10 0
Rt. St	8.76	. .	2	5 0	4	3 6	9 12 0	
Rt. St	8.76	. .	2	5 0	4	3 6	9 12 0	
Rothv	10.62	5.93	2	5 0	4	3 6		
Rothv	10.62	5.93	2	5 0	4	3 6		
Rothv	10.62	5.93	2	5 0	4	3 6		
Sharp	10.56	4.25	2	5 0	4	3 0		
Rt. St	8.76	. .	2	5 0	4	3 6		
Rt. St	8.76	. .	2	5 0	4	3 6		
Rothv	10.62	5.93	2	5 0	4	3 6		
Rothv	10.62	5.93	2	5 0	4	3 6		
Sharp	10.56	4.25	2	5 0	4	{ 3 6 } { 3 0 }	. . . .	12 5 0
Sharp	10.56	4.25	2	5 0	4	{ 3 6 } { 3 0 }	. . . .	12 5 0
Sharp	10.56	4.25	2	5 0	4	{ 3 6 } { 3 0 }	. . . .	12 5 0
Sharp	10.56	4.25	2	5 0	4	{ 3 6 } { 3 0 }	. . . .	12 5 0
Sharp	12.18	4.25	2	5 0	4	{ 3 6 } { 3 0 }	. . . .	12 5 0
Sharp	12.18	4.25	2	5 0	4	{ 3 6 } { 3 0 }	. . . .	12 5 0
Sharp	12.18	4.25	2	5 0	4	{ 3 6 } { 3 0 }	. . . .	12 5 0
Sharp	12.18	4.25	2	5 0	4	{ 3 6 } { 3 0 }	. . . .	12 5 0
Sharp	12.18	4.25	2	5 0	4	3 0		
Tayle	. .	. .	2	5 6	4	3 6		
Tayle	. .	. .	2	5 6	4	3 6		
Tayle	. .	. .	2	5 6	4	3 6		
Sharp	12.18	4.25	2	5 6	4	3 6	. . . .	12 15 0
Jones	. .	. .	2	5 0	4	{ 5 0 } { 3 0 }		
Tayle	. .	. .	2	5 6	4	3 6		

NES.

RAILWAY—(continued.)

DIMENSIONS OF FIRE-BOX.				DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
Width.	Height above the Grate Bars.	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Sectional Area in Inches.	Of Steam Passage.	Of Blast Pipe.	Driving.		Carrying.		In Working Trim.	Empty.
								No.	Diameter in Feet.	No.	Diameter in Feet.		
inches.	inches.	sq. ft.		ft. ins.					ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
52½	36	51·17	15	5 10	12·18	4·25	2	6 0	4	3 6	6	....	16 0 0
52½	36	51·17	15	5 10	12·18	4·25	2	6 0	4	3 6	6	....	16 0 0
46	46	52·35	10½	..	11·68	..	2	8 0	4	4 6	6		
46	46	52·35	10½	..	11·68	..	2	8 0	4	4 6	6		
46	46	52·35	10½	..	11·68	..	2	8 0	4	4 6	6		
42	41	47·17	14½	5 6	20·31	..	2	6 4	4	3 6	6		
42	41	47·17	14½	5 6	20·31	..	2	6 4	4	3 6	6		
44	42	51·71	..	..	..	..	2	8 0	4	4 0	0		
60	47	108·26	16	..	..	..	2	6 0	2	6 0	0	12 10 0	
60	47	108·26	16	..	..	..	2	10 0	4	4 6	6	11 10 0	
44	42	51·71	..	..	..	..	2	8 0	4	4 0	0		
44	42	51·71	..	..	..	..	2	8 0	4	4 0	0		
48	46½	68·42	17	15 0	14·36	..	2	6 6	4	4 0	0	12 12 2	11 9 0
47	45½	68·91	15½	16 5	15·31	7·06	2	7 0	4	4 0	0		
47	45½	68·91	15½	16 5	15·31	7·06	2	7 0	4	4 0	0		
44	42	51·71	..	..	..	..	2	8 0	4	4 0	0		
46½	..	..	..	..	..	..	2	7 0	4	4 0	0		
44½	49	70·42	..	..	..	..	2	6 0	4	3 6	6		
46½	54	77·88	16	6 0	13·75	11·04	2	7 0	4	4 0	0		
46½	54	77·88	16	6 0	13·75	11·04	2	7 0	4	4 0	0		
42½	42½	62·14	15½	15 2	16·56	10·32	2	7 0	4	4 0	0		

JINGTON RAILWAY.

inches.	inches.	sq. ft.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
49	..	..	13½	..	..	..	2	4 6	2	4 6	....	10 8 2
49	..	..	13½	..	..	..	2	4 6	2	4 6	....	10 8 2
49	17	27·03	..	..	..	..	2	5 0	2	5 0	....	9 9 2
42	43½	53·63	13½	12 0	10·31	..	2	4 5½	4	4 5½		
40	41	40·26	14	5 6	13·75	..	2	4 6	4	3 6		
40	54	64·13	..	..	..	..	2	4 6	4	4 6		

Maker's Name.	WHEELS.			WEIGHT OF ENGINE.	
	g.	Carrying.		In Working Trim.	Empty.
	Diameter in Feet.	No.	Diameter in Feet.		
	ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
Rt. Stephenson & Co. .	0	2	3 6		
Rt. Stephenson & Co. .	0	2	3 6		
Fenton & Co.	0	2	3 6		
Fenton & Co.	0	2	3 6		
Rt. Stephenson & Co. .	0	2	3 6	9 12 3	
Rt. Stephenson & Co. .	0	4	{ 5 0 3 6 }		
Rt. Stephenson & Co. .	0	4	{ 3 6 3 0 }	13 12 1	
Rt. Stephenson & Co. .	0	2	3 6	11 4 3	
Fenton & Co.	0	2	3 6		
Rt. Stephenson & Co. .	0	2	3 6		
Rt. Stephenson & Co. .	0	4	{ 5 0 3 6 }	14 8 0	
Tayleur & Co.	0	2	3 0	13 7 2	
Tayleur & Co.	0	2	3 0		
Forrester & Co.	0	4	3 6		
Tayleur & Co.	0	4	{ 3 6 3 0 }		
Tayleur & Co.	0	4	{ 3 6 3 0 }		
Mather, Dixon, & Co. .	0	2	5 0		
Tayleur & Co.	0	4	{ 5 0 3 0 }		
Tayleur & Co.	0	2	3 6		
Tayleur & Co.	0	4	{ 5 0 3 0 }		
Haigh Foundry Co. . .	0	4	{ 3 6 3 0 }		
Mather & Co.	0	4	{ 5 0 3 0 }		
Haigh Foundry Co. . .	0	4	{ 3 6 3 0 }	11 11 1	
Haigh Foundry Co. . .	0	4	{ 3 6 3 0 }	12 8 0	
Tayleur & Co.	0	4	3 6	12 11 2	
Tayleur & Co.	0	4	3 6		
Mather, Dixon, & Co. .	0	4	3 6		
Tayleur & Co.	0	4	3 6	12 9 1	
Tayleur & Co.	0	4	3 6	13 0 2	
Mather, Dixon, & Co. .	0	4	3 6	10 13 1	

NES.

IR RAILWAY—(continued.)

DIMENSIONS OF FIRE-BOX.			DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
Width.	Height above the Grate Bars.	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Of Steam Passage.	Of Blast Pipe.	Driving.		Carrying.		In Working Trim.	Empty.
					Sectional Area in Inches.	Sectional Area in Inches.	No.	Diameter in Feet.	No.	Diameter in Feet.		
inches.	inches.	sq. ft.	ft. ins.	ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
41½	37	43·22	12½	4 10	..	..	2	5 0	4	3 6	12 12 0	
40	33½	38·82	..	..	..	..	2	5 0	4	3 6		
40	34	39·32	12½	4 9	..	..	2	5 0	4	3 6	12 1 2	
41	36	41·47	12	5 2	..	..	2	5 0	4	3 6	12 12 2	
39	36	39·78	12	5 2	..	..	2	5 0	4	{ 5 0 3 6 }		
40½	36½	41·08	..	..	..	..	2	5 0	4	{ 5 0 3 6 }	14 9 2	
41	40¾	46·33	..	..	..	..	2	5 0	4	3 6	14 15 2	
41	39¾	45·08	..	..	..	..	2	5 0	4	3 6	14 13 2	
40½	38	41·33	13	5 6	..	..	2	5 0	4	{ 5 0 3 0 }	13 19 0	
40	38	42·02	12	5 3	..	..	2	5 0	4	3 6	13 13 0	
39½	38	39·83	13	4 10	..	..	2	5 0	4	{ 5 0 3 0 }	14 5 2	
40	38	42·02	12	5 2	..	..	2	5 0	4	3 6	13 4 0	
39	40¾	44·33	..	..	..	..	2	5 0	4	{ 5 0 3 6 }		
39	36	39·77	12	5 2	..	..	2	5 0	4	{ 5 0 3 6 }		
40½	42¾	47·44	..	..	..	..	2	5 0	4	{ 5 0 3 6 }	15 3 2	
40½	42¾	47·44	12	5 0	..	..	2	5 0	4	{ 5 0 3 6 }	15 3 0	
40	33	52·32	..	..	..	..	2	4 6	4	{ 5 0 3 6 }		
24	31	22·44	14	..	..	..	2	4 8	2	2 6		
..	..	..	..	..	..	..	2	5 0	2	3 8		
..	..	..	..	..	..	..	2	5 0	2	2 8		
40	34	32·53	..	..	..	..	2	5 0	2	2 8		
45	37	40·00	12½	..	..	..	2	4 6	2	4 6	....	10 0 0
45	37	40·00	12½	..	..	..	2	4 6	2	4 6		
43½	29½	30·94	11½	..	..	..	2	5 0	2	3 0	....	7 16 0
43	37	44·35	12½	..	..	..	2	5 0	2	3 6	....	9 11 0
42¾	37	36·46	..	..	..	..	2	5 0	2	3 0	....	7 18 0
43½	37	36·74	13	..	..	..	2	5 0	2	3 0	....	8 0 0
43	42	43·68	13½	..	..	..	2	5 0	2	3 6	....	8 14 0
..	..	..	..	..	..	..	2	5 0	2	2 8		
..	..	..	..	..	..	..	2	5 0	2	3 0		
42	37½	37·67	12½	..	..	..	2	5 0	2	3 0		

Maker's Name.	No. in inches.	WHEELS.				WEIGHT OF ENGINE.	
		Driving.		Carrying.		In Working Trim.	Empty.
		No.	Diameter in Feet.	No.	Diameter in Feet.		
Locomotive Engines as originally constructed by Messrs. Rt. Stephenson & Co. for the Liverpool and Manchester Railway Company.		2	ft. ins. 5 0	2	ft. ins. 3 0	tons. cwt. qrs.	tons. cwt. qrs.
		2	5 0	2	3 0		
		2	5 0	2	3 0		
		2	5 0	2	3 6		
		2	5 0	2	3 0	....	8 1 1
		2	5 0	4 { 5 0 } 3 6 }		....	8 19 2
		2	5 0	4 { 5 0 } 3 0 }		....	8 19 2
		2	5 0	2	3 6		
Edward Bury							
Galloway & Co.							
Sharp & Roberts							

		ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
R. & W. Hawthorn ..	2	5 6	2	4 0	9 18 0	8 10 0
R. & W. Hawthorn ..	2	5 6	2	4 0	9 18 0	8 10 0
R. & W. Hawthorn ..	2	5 6	2	4 0	9 18 0	8 10 0
R. & W. Hawthorn ..	2	5 6	2	4 0	9 18 0	8 10 0
R. & W. Hawthorn ..	2	5 6	2	4 0	9 18 0	8 10 0
R. & W. Hawthorn ..	2	5 6	2	4 0	9 18 0	8 10 0
Haigh Foundry Co. ..	2	5 6	2	4 0		
Haigh Foundry Co. ..	2	5 6	2	4 0		
Haigh Foundry Co. ..	2	5 6	2	4 0		
Rothwell & Co.	2	5 6	2	4 0	....	10 0 1
Rothwell & Co.	2	5 6	2	4 0	....	10 0 1
Rothwell & Co.	2	5 6	2	4 0	....	10 0 1
Rothwell & Co.	2	5 6	2	4 0	....	10 0 1
Rothwell & Co.	2	5 6	2	4 0	....	10 0 1
Rothwell & Co.	2	5 6	2	4 0	....	10 0 1
Mather, Dixon, & Co.	2	5 6	2	4 6		

ILWAY—(continued.)

DIMENSIONS OF RE-BOX.		DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
				<i>Of Steam Passage.</i>	<i>Of Blast Pipe.</i>	<i>Driving.</i>		<i>Carrying.</i>			
Height above the Grate Bars.	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Sectional Area in Inches.	Sectional Area in Inches.	N ^o .	Diameter in Feet.	N ^o .	Diameter in Feet.	In Working Trim.	Empty.
inches.	supl feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
39	30·66	..	..	..	..	2	5 6	2	4 6		
39	30·66	..	..	..	..	2	5 6	2	4 6		
39	30·66	..	..	..	..	2	5 6	2	4 6		
39	30·66	..	..	..	..	2	5 6	2	4 6		
39	30·66	..	..	..	..	2	5 6	2	4 6		
38	48·38	16	14 6	8·08	..	2	5 0	4	3 6		
51	36·26	..	..	..	..	2	4 6	2	4 6		
44	33·81	..	..	..	..	2	4 6	2	4 6		
44	33·81	..	..	..	..	2	4 6	2	4 6		
44	33·81	..	..	..	..	2	4 6	2	4 6		
44	33·81	..	..	..	..	2	4 6	2	4 6		
44	33·81	..	..	..	..	2	4 6	2	4 6		
44	33·81	..	..	..	..	2	4 6	2	4 6		
44	33·81	..	..	..	..	2	4 6	2	4 6		

RAILWAY.

Inches.	sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
36	46·62	15	5 10	12·18	4·25	2	5 6	4	3 6	....	12 10 0
36	46·62	15	5 10	12·18	4·25	2	5 6	4	3 6	....	12 10 0
36	46·62	15	5 10	12·18	4·25	2	5 6	4	3 6	....	12 10 0
55½	69·74	15	5 0	12·37	7·06	2	5 6	4	3 6	15 12 0	14 0 0
55½	69·74	15	5 0	12·37	7·06	2	5 6	4	3 6		

RAILWAY.

Inches.	sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
36	46·62	14	5 10	12·18	4·25	2	5 6	4	3 6	....	12 10 0
36	46·62	14	5 10	12·18	4·25	2	5 6	4	3 6	....	12 10 0
36	46·62	14	5 10	12·18	4·25	2	5 6	4	3 6	....	12 10 0
36	46·62	14	5 10	12·18	4·25	2	5 6	4	3 6	....	12 10 0
36	46·62	14	5 10	12·18	4·25	2	5 6	4	3 6	....	12 10 0
48	60·14	14	5 6	11·85	7·06	2	5 6	4	3 6	14 5 0	13 0 0
48	60·14	14	5 0	11·85	7·06	2	5 6	4	3 6	14 5 0	13 0 0

Maker's Name.	WHEELS.				WEIGHT OF ENGINE.	
	No of Engine. N ^o .	Driving.	Carrying.		In Working Trim.	Empty.
		Diameter in Feet.	N ^o .	Diameter in Feet.		
		ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
Taylor & Co.	1 2	5 0	2	3 9		
Marshall	2 2	5 0	2	3 9		
Marshall	3 2	5 0	4	3 9		
Marshall	4 2	5 0	2	4 0		
G. Forrester & Co. . . .	5 2	5 0	2	4 0		
G. Forrester & Co. . . .	6 2	5 0	2	4 0		
Day	7 2	5 0	4	3 9		
R. & W. Hawthorn . .	8 2	5 6	4	4 0		
Rt. Stephenson & Co. .	9 2	6 0	4	4 0		

[illegible]

ES.

IN RAILWAY—(continued.)

DIMENSIONS OF FIRE-BOX.			DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
					Of Steam Passage.	Of Blast Pipe.	Driving.		Carrying.			
Height above the Grate Bars.	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Sectional Area in Inches.	Sectional Area in Inches.	N ^o .	Diameter in Feet.	N ^o .	Diameter in Feet.	In Working Trim.	Empty.	
inches.	sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.	
46	53·28	13	5 3	12·00	5·93	2	5 6	4	3 6	....	13 4 1
46	53·28	13	5 3	12·00	5·93	2	5 6	4	3 6	....	13 4 1
46	53·28	13	5 3	12·00	5·93	2	5 6	4	3 6	....	13 4 1
46	53·28	13	5 3	12·00	5·93	2	5 6	4	3 6	....	13 4 1
46	53·28	13	5 3	12·00	5·93	2	5 6	4	3 6	....	13 4 1
48	60·13	14	5 6	11·85	7·06	2	5 6	4	3 6	14 5 0	13 0 0	
48	60·13	14	5 6	11·85	7·06	2	5 6	4	3 6	14 5 0	13 0 0	
..	..	14	6 6	6·25	3·25	2	5 6	2	4 0			
48	60·13	14	5 6	11·85	3·00	2	5 6	4	3 6	14 5 0	13 0 0	
48	60·13	14	5 6	11·85	3·00	2	5 6	4	3 6	14 5 0	13 0 0	

TON RAILWAY.

inches.	sup ^l feet.	ft. ins.					ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
43	36·47	13	13 1	{ Ind ⁿ 5·90 Ed ⁿ 9·18 }	7·06	2	5 0	2	5 0	10 7 2	8 13 2
43	36·47	13	13 1	{ Ind ⁿ 5·90 Ed ⁿ 9·18 }	7·06	2	5 0	2	5 0	10 7 2	8 13 2
43	36·47	13	13 1	{ Ind ⁿ 5·90 Ed ⁿ 9·18 }	7·06	2	5 0	2	5 0	10 7 2	8 13 2
43	36·47	13	13 1	{ Ind ⁿ 5·90 Ed ⁿ 9·18 }	7·06	2	5 0	2	5 0	10 7 2	8 13 2
43	36·47	13	13 1	{ Ind ⁿ 5·90 Ed ⁿ 9·18 }	7·06	2	5 0	2	5 0	10 7 2	8 13 2
43	36·47	13	13 1	{ Ind ⁿ 5·90 Ed ⁿ 9·18 }	7·06	2	5 0	2	5 0	10 7 2	8 13 2
43	36·47	13	13 1	{ Ind ⁿ 5·90 Ed ⁿ 9·18 }	7·06	2	5 0	2	5 0	10 7 2	8 13 2
38½	27·53	12	12 4	{ Ind ⁿ 4·12 Ed ⁿ 6·18 }	3·97	2	5 0	2	3 6	10 13 0	8 19 0
38½	27·53	12	12 4	{ Ind ⁿ 4·12 Ed ⁿ 6·18 }	3·97	2	5 0	2	3 6	10 13 0	8 19 0

Maker's Name.	B. Of Blast Pipe. Sectional Area in Inches.	WHEELS.				WEIGHT OF ENGINE.	
		Driving.		Carrying.		In Working Trim.	Empty.
		Nº.	Diameter in Feet.	Nº.	Diameter in Feet.		
Sharp, Roberts, & Co..	4·25	2	ft. ins. 5 0	4	ft. ins. { 5 0 3 6 }	....	15 0 0
Sharp, Roberts, & Co..	4·25	2	5 0	4	{ 5 0 3 6 }	....	15 0 0
Sharp, Roberts, & Co..	4·25	2	5 0	4	{ 5 0 3 6 }	....	15 0 0
Nasmyth & Co.	3·25	2	5 0	4	{ 5 0 3 6 }		
Nasmyth & Co.	3·25	2	5 0	4	{ 5 0 3 6 }		
Nasmyth & Co.	3·25	2	5 0	4	{ 5 0 3 6 }		
Rt. Stephenson & Co..	...	2	5 0	4	{ 5 0 3 6 }		
Rt. Stephenson & Co..	...	2	5 0	4	{ 5 0 3 6 }		
Rt. Stephenson & Co..	...	2	5 0	4	{ 5 0 3 6 }		
Nasmyth & Co.	3·25	2	5 0	4	{ 5 0 3 6 }		
Nasmyth & Co.	3·25	2	5 0	4	{ 5 0 3 6 }		
Nasmyth & Co.	3·25	2	5 0	4	{ 5 0 3 6 }		
Tayleur & Co. ....	...	2	5 6	4	{ 5 6 3 6 }		
Tayleur & Co. ....	..	2	5 6	4	{ 5 6 3 6 }		

			ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
Stark & Fulton	10·56	2	5 6	2	4 0	10 0 0	8 10 0
E. Bury .....	..	2	5 6	2	4 0	10 0 0	8 10 0
E. Bury .....	..	2	5 6	2	4 0	10 0 0	8 10 0
Stark & Fulton	10·56	2	5 6	2	4 0	10 0 0	8 10 0
Stark & Fulton	10·56	2	5 6	2	4 0	10 0 0	8 10 0
Nasmyth & Co.	10·56	2	5 6	2	4 0	10 0 0	8 10 0
Nasmyth & Co.	10·56	2	5 6	2	4 0	10 0 0	8 10 0
Nasmyth & Co.	10·56	2	5 6	2	4 0	10 0 0	8 10 0

E RAILWAY.

DIMENSIONS OF FIRE-BOX.		DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
Height above the Grate Bars.	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Of Steam Passage.	Of Blast Pipe.	Driving.		Carrying.		In Working Trim.	Empty.
						No.	Diameter in Feet.	No.	Diameter in Feet.		
Inches.	supl feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
38½	37·14	13	..	..	..	2	4 0	2	4 0	8 10 0	7 5 0
43	53·10	14½	..	..	..	2	4 6	4	{4 6 3 6}	11 15 0	10 5 0
43	53·10	15	..	..	..	2	4 0	4	4 0	13 0 0	11 15 0
43	48·18	15	..	..	..	2	4 6	2	4 6	10 18 0	9 10 0
43	53·10	15	..	..	..	2	4 0	4	4 0	13 0 0	11 15 0
44	55·03	15	..	..	..	2	5 0	4	{5 0 4 0}	13 5 0	12 0 0
44	55·03	13	..	..	..	2	4 0	4	4 0	13 5 0	12 0 0
44	55·03	13	..	..	..	2	4 9	4	{4 9 3 6}	13 5 0	12 0 0
44	55·03	13	..	..	..	2	4 9	4	{4 9 3 6}	13 5 0	12 0 0
44	55·03	15	..	..	..	2	5 0	4	{5 0 4 0}	13 5 0	12 0 0
44	55·03	15	..	..	..	2	5 0	4	{5 0 4 0}	13 5 0	12 0 0
44	55·03	13	..	..	..	2	5 0	4	{5 0 4 0}	13 5 0	12 0 0
42½	52·81	17	12 6	10·99	..	2	4 6	4	{4 6 3 6}		
40	46·71	14¾	12 6	10·99	..	2	4 6	4	{4 6 3 6}	11 6 0	10 6 2
43½	53·88	15	12 6	10·99	..	2	4 0	4	4 0	11 6 3	10 6 0
32½	35·72	15	12 6	8·08	..	2	4 0	4	4 0	8 4 0	7 8 1

LDS RAILWAY.

Inches.	supl feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
40½	46·98	12¾	13 6	10·00	..	2	6 0	4	{4 0 4 6}		
40¾	46·19	12	..	..	..	2	5 6	4	3 6	11 0 0	9 15 0
40¾	46·19	12	..	..	..	2	5 6	4	3 6	11 0 0	9 15 0
46	46·97	13	..	..	..	2	4 9	4	{4 9 3 6}	13 0 0	11 15 0
45	58·45	14¾	12 6	13·75	5·93	2	4 9	4	{4 9 3 6}		
45 } 45 }	132·32	..	..	..	..	2	4 9	4	{4 9 3 6}		

Maker's Name.	Z.E. Of Blast Pipe.	WHEELS.				WEIGHT OF ENGINE.	
		Driving.		Carrying.		In Working Trim.	Empty.
		No.	Diameter in Feet.	No.	Diameter in Feet.		
	Sectional Area in Inches.		ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
R. & W. Hawthorn (2	. .	2	6 0	4	4 0		
R. & W. Hawthorn (2	. .	2	6 0	4	4 0		
R. & W. Hawthorn (2	. .	2	6 0	4	4 0		
Mather, Dixon, & Co.	. .	2	5 6	4	3 6		
Mather, Dixon, & Co.	. .	2	5 6	4	3 6		
Mather, Dixon, & Co.	. .	2	5 6	4	3 6		
Tayleur & Co. (98) .	. .	2	5 6	4	3 6		
Tayleur & Co. (99) .	. .	2	5 6	4	3 6		
Tayleur & Co. (100)	. .	2	6 0	4	4 0		
Tayleur & Co. (101)	. .	2	6 0	4	4 0		
Tayleur & Co. (102)	. .	2	6 0	4	4 0		
Tayleur & Co. (105)	. .	2	5 6	4	3 6		
Tayleur & Co. (108)	. .	2	5 0	2	3 6		
Rt. Stephenson & Co.	4·90	2	6 0	4	4 0		
Rt. Stephenson & Co.	7·66	2	5 0	4	$\left\{ \begin{smallmatrix} 5 & 0 \\ 3 & 6 \end{smallmatrix} \right.$		
Rt. Stephenson & Co.	7·06	2	6 0	4	4 0		
Rt. Stephenson & Co.	7·06	2	6 0	4	4 0		
Rt. Stephenson & Co.	7·06	2	5 6	4	$\left\{ \begin{smallmatrix} 5 & 6 \\ 3 & 6 \end{smallmatrix} \right.$		
Rt. Stephenson & Co.	10·56	2	6 0	4	4 0		
Rt. Stephenson & Co.	7·06	2	6 0	4	4 0		

			ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
Haigh Foundry Co. .	. .	2	4 6	2	3 6	7 10 0	
Jones, Turner, & Eva	. .	2	5 6	2	4 0	9 0 0	
Jones, Turner, & Eva	. .	2	5 6	2	4 0	9 0 0	
Benjamin Hick & Co.	. .	2	5 6	2	4 0	9 0 0	
Benjamin Hick & Co.	. .	2	5 6	2	4 0	9 0 0	
Benjamin Hick & Co.	. .	2	5 6	2	4 0	9 0 0	
Benjamin Hick & Co.	. .	2	5 6	2	4 0	9 0 0	
Haigh Foundry Co. .	. .	2	5 6	2	4 0	9 0 0	
Haigh Foundry Co. .	. .	2	5 6	2	4 0	9 0 0	
Haigh Foundry Co. .	. .	2	5 6	2	4 0	9 0 0	
Jones, Turner, & Eva	. .	2	5 6	2	4 0	9 0 0	
Jones, Turner, & Eva	. .	2	5 0	4	$\left\{ \begin{smallmatrix} 3 & 4 \\ 3 & 0 \end{smallmatrix} \right.$	9 0 0	
Bourne, Bartley, & C	. .	2	5 0	4	$\left\{ \begin{smallmatrix} 3 & 8 \\ 2 & 10 \end{smallmatrix} \right.$	11 0 0	

RAILWAY.

SIZES OF ENGINES.		DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
				Of Steam Passage.	Of Blast Pipe.	Driving.		Carrying.			
Grate Bars.	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Sectional Area in Inches.	Sectional Area in Inches.	No.	Diameter in Feet.	No.	Diameter in Feet.	In Working Trim.	Empty.
sq. ft.	sq. ft.	ft. ins.	ft. ins.	sq. ft.	sq. ft.		ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
3	38.40	13	13 9½	6.37	..	2	5 0	4	3 6	11 15 0	10 5 0
1½	53.37	13½	14 0	7.43	..	2	4 6	4	{ 4 6 3 6		
3½	50.37	13½	14 0	7.43	..	2	4 6	4	{ 4 6 3 6		
3	50.95	13½	14 0	7.43	..	2	4 6	4	{ 4 6 3 6		
3½	59.95	..	..	..	..	2	4 6	4	{ 4 6 3 6
..	..	..	..	..	..	2	4 0	4	4 0
2	52.22	14	..	..	..	2	4 6	4	{ 4 6 3 6
1½	55.33	15½	13 6	..	..	2	4 6	4	{ 4 6 3 6
..	..	..	..	..	..	2	4 0	4	4 0
1½	..	15½	13 6	..	..	2	4 6	4	4 6

RAILWAY.

es.	supl feet.	ft. ins.	ft. ins.	ft. ins.	ft. ins.	ft. ins.	ft. ins.	ft. ins.	ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
7½	41.19	11½	15 6	9.37	..	2	5 6	4	3 9		
3	52.48	12¾	13 6	10.00	..	2	5 6	4	3 9		
3	52.48	12¾	13 6	10.00	..	2	5 6	4	3 9		
7½	41.19	11½	13 6	9.37	..	2	5 6	4	3 9		
7½	41.19	11½	13 6	9.37	..	2	5 6	4	3 9		
9½	47.89	12½	13 9	10.31	4.90	2	5 6	4	3 9		
9¾	48.81	12¾	13 6	10.00	4.90	2	5 6	4	3 9		
9½	48.45	13	14 0	10.31	4.90	2	5 6	4	3 9		

S.

Maker's Name	SIZE.		WHEELS.				WEIGHT OF ENGINE.	
	Team size.	Of Blast Pipe.	Driving.		Carrying.		In Working Trim.	Empty.
	Area in Inches.	Sectional Area in Inches.	Nº.	Diameter in Feet.	Nº.	Diameter in Feet.		
Rt. Stephenson & 400	. .	2	ft. ins.	4 3 6	ft. ins.	4 3 6	tons. cwt. qrs.	tons. cwt. qrs.
Rt. Stephenson & 400	. .	2	5 0	4 3 6	5 0	4 3 6		
Rt. Stephenson & 59	. .	2	4 6	4 { 4 6 3 6	4 6	{ 4 6 3 6		
Rt. Stephenson & 59	. .	2	4 6	4 { 4 6 3 6	4 6	{ 4 6 3 6		
Rt. Stephenson & 59	. .	2	4 6	4 { 4 6 3 6	4 6	{ 4 6 3 6		
Rt. Stephenson & 59	. .	2	4 6	4 { 4 6 3 6	4 6	{ 4 6 3 6		
Rt. Stephenson & 59	. .	2	4 6	4 { 4 6 3 7	4 6	{ 4 6 3 7		
Sharp, Roberts, & 18	4.25	2	5 6	4 3 6	5 6	4 3 6	. . . .	11 0 0
Sharp, Roberts, & 18	4.25	2	5 6	4 3 6	5 6	4 3 6	. . . .	11 0 0
Sharp, Roberts, & 18	4.25	2	5 6	4 3 6	5 6	4 3 6	. . . .	11 0 0

			ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
Rothwell & Co. (400	4.42	2	4 6	2	3 0		
Rothwell & Co. (500	4.42	2	4 6	2	3 0		
Rothwell & Co. (600	5.41	2	4 6	2	3 0		
Rothwell & Co. (700	5.41	2	4 6	2	3 0		
Rothwell & Co. (800	4.90	2	4 6	2	3 0		
Rt. Stephenson & .	. .	2	4 6	2	4 6		
Rt. Stephenson & .	. .	2	4 8 $\frac{3}{4}$	2	4 4		
Rt. Stephenson & 61	. .	2	5 0	2	3 6	. . . .	6 2 0
Rt. Stephenson & 61	. .	2	5 0	2	3 6		
Rt. Stephenson & 61	. .	2	5 0	2	3 6		
Rt. Stephenson & 61	. .	2	4 6	2	4 6	7 4 2	6 11 1
Rt. Stephenson & 61	. .	2	4 0	2	4 0	7 5 0	6 9 0
Rt. Stephenson & 61	. .	2	4 0	2	4 0	7 5 0	6 9 0

ed.)

OF	DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
			Of Steam Passage.	Of Blast Pipe.	Driving.		Carrying.			
	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Sectional Area in Inches.	Sectional Area in Inches.	N ^o .	Diameter in Feet.	N ^o .	Diameter in Feet.	In Working Trim.	Empty.
sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
29-32	12½	14 0	5-61	..	2	5 0	2	3 6	6 11 3	5 16 1
29-32	12½	14 0	5-61	..	2	5 0	2	3 6	6 11 3	5 16 1
57-51	19 × 15½	13 7	12-62	..	2	4 6	4	{ 4 6 3 2		
57-51	19 × 15½	13 7	12-62	..	2	4 6	4	{ 4 6 3 2		
40-35	..	..	..	..	2	4 4	2	4 4		
30-08	12	..	..	..	2	4 0	2	4 0		
36-95	11½	15 0	5-25	..	2	4 5	2	4 5	6 4 1	5 7 1
32-06	12½	..	5-61	..	2	4 4	2	4 4	7 10 0	
30-75	12¾	14 6	5-61	..	2	4 6	2	4 6	7 14 1	6 8 3
43-80	15	14 6	8-08	..	2	5 0	4	3 6	10 5 2	8 11 0
42-79	..	..	..	..	2	4 6	2	4 6		
42-79	..	..	..	..	2	4 6	2	4 6		
42-79	..	..	..	..	2	5 6	2	4 6		
45-35	11¾	6 0	5-50	2-76	2	4 6	2	4 6		
35-59	10	6 9	6-00	5-41	2	5 0	2	3 0		
..	11	7 10	5-25	4-90	2	4 6	2	4 6	....	7 1 0
..	11	7 10	5-25	4-90	2	4 6	2	4 6	....	7 1 0
46-82	12	7 10	6-18	..	2	4 6	4	{ 3 0 2 6	7 10 0	6 13 0
27-34	11½	12 0	4-54	..	2	4 0	2	4 0	5 12 0	5 2 0

Maker's	Sectional Area in Inches.	WHEELS.				WEIGHT OF ENGINE.	
		Driving.		Carrying.		In Working Trim.	Empty.
		Nº.	Diameter in Feet.	Nº.	Diameter in Feet.		
			ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
Sharp, Roberts, £4·25		2	5 6	4	3 6	....	12 5 0
Sharp, Roberts, £4·25		2	5 6	4	3 6	....	12 5 0

		ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
Tayleur & Co. . . .	2	4 6	4	{ 4 6 3 6		
Rt. Stephenson & . .	2	4 6	4	{ 4 6 3 6		
Rt. Stephenson & . .	2	5 0	4	3 6	10 5 0	9 6 2
Rt. Stephenson & . .	2	5 0	4	3 6		
Rt. Stephenson & . .	2	4 6	4	{ 4 6 3 6		
Rt. Stephenson & . .	2	4 6	4	{ 4 6 3 6		
Rt. Stephenson & . .	2	4 6	4	{ 4 6 3 6		
Rt. Stephenson & . .	2	4 6	4	{ 4 6 3 6		
Rt. Stephenson & . .	2	5 0	4	3 6		
Rt. Stephenson & . .	2	5 0	4	3 6		
Rt. Stephenson & . .	2	5 0	4	3 6		
Rt. Stephenson & . .	2	4 6	4	{ 4 6 3 6		
Rt. Stephenson & . .	2	5 0	4	3 6		
Rt. Stephenson & . .	2	5 0	4	3 6		
Rt. Stephenson & . .	2	5 0	4	{ 5 0 3 6		
Rt. Stephenson & . .	2	5 6	4	3 9		
Rt. Stephenson & . .	2	5 6	4	3 9		
Rt. Stephenson & . .	2	5 6	4	3 9		
Rt. Stephenson & . .	2	5 6	4	3 9		
Rt. Stephenson & . .	2	5 6	4	3 9		
Rt. Stephenson & . .	2	5 6	4	3 9		
Rt. Stephenson £4·90	2	5 6	4	3 9		
Sharp, Roberts, £4·25	2	5 6	4	3 6	....	12 5 0

WAY.

No. of Engines.	DIMENSIONS OF CHIMNEY.			SIZE.		WHEELS.				WEIGHT OF ENGINE.	
				Of Steam Passage.	Of Blast Pipe.	Driving.		Carrying.			
	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Sectional Area in Inches.	Sectional Area in Inches.	No.	Diameter in Feet.	No.	Diameter in Feet.	In Working Trim.	Emp
Grate Data.											
sup ^l feet.		ft. ins.					ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt.
45·39	15½	13 6	8·08	..	2	6 0	4	4 0			
45·39	15½	13 6	8·08	..	2	6 0	4	4 0			
46·81	12½	13 6	8·08	..	2	5 0	4	3 6			
46·81	12½	13 6	8·08	..	2	5 0	4	3 6			
57·38	14½	13 6	10·99	..	2	5 0	4	5 0 3 6			
57·38	14½	13 6	10·99	..	2	5 0	4	5 0 3 6			

WAY.

	supl feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt.
	47·97	12½	13 6	..	..	2	6 0	4	4 0		
	47·64	12½	13 6	..	..	2	6 0	4	4 0		
	52·54	13	13 6	..	..	2	6 0	4	4 0		
	52·54	13	13 6	..	..	2	6 0	4	4 0		
	53·77	..	..	..	..	2	5 6	4	3 6		
	53·77	..	..	..	..	2	5 6	4	3 6		
	53·22	..	..	..	..	2	5 6	4	3 6		
	53·22	..	..	..	..	2	5 6	4	3 6		

WAY.

	supl feet.		above Smoke-box. ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt.
	..	12	6 3	6·00	5·41	2	4 6	2	4 6	....	8 0
	..	13	5 9	6·00	5·41	2	5 0	2	5 0	....	9 0
	..	13	5 9	6·00	5·41	2	5 0	2	5 0	....	9 0
	..	12	6 0	6·00	5·41	2	4 6	2	4 6	....	8 0
	48·69	12	5 6	12·00	5·93	2	5 0	4	3 6	....	12 0
	48·69	12	5 6	12·00	5·93	2	5 0	4	3 6	....	12 0
	48·69	12	5 6	12·00	5·93	2	5 0	4	3 6	....	12 0
	48·69	12	5 6	12·00	5·93	2	5 0	4	3 6	....	12 0
	48·69	12	5 6	12·00	5·93	2	5 0	4	3 6	....	12 0
	48·69	12	5 6	12·00	5·93	2	5 0	4	3 6	....	12 0
	35·47	12½	above Rails. 13 6	10·00	..	2	5 0	4	3 6		

Maker's Name.	WHEELS.				WEIGHT OF ENGINE.	
	Driving.		Carrying.		In Working Trim.	Empty.
	Nº.	Diameter in Feet.	Nº.	Diameter in Feet.		
	ft.	ins.		ft.	ins.	tons. cwt. qrs.
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0

	ft.	ins.		ft.	ins.	tons. cwt. qrs.	tons. cwt. qrs.
Sharp, Roberts, & Co	5	0	4	5 0 3 6		15 0 0	
Sharp, Roberts, & Co	5	0	4	3	6	9 5 0	
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0	
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0	

	ft.	ins.		ft.	ins.	tons. cwt. qrs.	tons. cwt. qrs.
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0	
Sharp, Roberts, & Co	5	6	4	3	6	12 0 0	
Rt. Stephenson & Co	5	0	4	3	6		
Rt. Stephenson & Co	5	0	4	3	6		

	ft.	ins.		ft.	ins.	tons. cwt. qrs.	tons. cwt. qrs.
R. & W. Hawthorn	6	0	4	3	6	12 0 0	10 15 0
R. & W. Hawthorn	6	0	4	3	6	12 0 0	10 15 0
Sharp, Roberts, & Co	6	0	4	3	6	13 0 0	
Sharp, Roberts, & Co	6	0	4	3	6	13 0 0	
Sharp, Roberts, & Co	6	0	4	3	6	13 0 0	

7AY—(continued.)

DIMENSIONS OF RE-BOX.		DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
				Of Steam Passage.	Of Blast Pipe.	Driving.		Carrying.			
						Height above the Grate Bars.	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Sectional Area in Inches.	Sectional Area in Inches.	N^{o}.	Diameter in Feet.	N^{o}.	Diameter in Feet.	In Working Trim.	Empty.
inches.	sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
36	46·04	14	5 10	12·18	4·25	2	6 0	4	3 6	....	13 0 0
36	46·04	14	5 10	12·18	4·25	2	6 0	4	3 6	....	13 0 0
48½	62·07	13½	13 6	12·18	..	2	5 6	4	3 6		
40	45·37	..	..	..	..	2	6 0	4	3 6		
40	45·37	..	..	..	..	2	6 0	4	3 6		

IN RAILWAY.

inches.	sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
38	42·02	14	..	..	..	2	5 0	2	4 0	9 13 0	8 11 0
38	42·02	14	..	..	..	2	5 0	2	4 0	9 13 0	8 11 0
46	46·38	..	..	..	..	2	5 6	4	3 6		
46	46·38	..	..	..	..	2	5 6	4	3 6		
46	46·38	..	..	..	..	2	5 6	4	3 6		
46	46·38	..	..	..	..	2	5 6	4	3 6		
46	46·38	..	..	..	..	2	5 6	4	3 6		
46	46·38	..	..	..	..	2	5 6	4	3 6		
40½	44·79	14	5 6	10·68	..	2	5 6	4	{ 4 0 3 6		
40½	44·79	14	5 6	10·68	..	2	5 6	4	{ 4 0 3 6		
40½	44·79	14	5 6	10·68	..	2	5 6	4	{ 4 0 3 6		
40½	44·79	14	5 6	10·68	..	2	5 6	4	{ 4 0 3 6		

RAILWAY.

inches.	sup ^l feet.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
40¾	46·10	14	..	..	..	2	5 6	4	3 6	11 0 0	9 15 0
40¾	46·10	14	..	..	..	2	5 6	4	3 6	11 0 0	9 15 0
40¾	46·10	14	..	..	..	2	5 6	4	3 6	11 0 0	9 15 0
40¾	46·10	14	..	..	..	2	5 6	4	3 6	11 0 0	9 15 0
48	56·22	14½	5 3	12·00	5·93	2	5 6	4	3 6	....	13 0 0
48	56·22	14½	5 3	12·00	5·93	2	5 6	4	3 6	....	13 0 0

Maker's Name.	Blast pe.	WHEELS.				WEIGHT OF ENGINE.	
		Driving.		Carrying.		In Working Trim.	Empty.
		Nº.	Diameter in Feet.	Nº.	Diameter in Feet.		
	Area in Inches.						
Rothwell & Co.	93	2	ft. ins. 5 6	4	ft. ins. 3 6	tons. cwt. qrs.	tons. cwt. qrs. 13 0 0
Rothwell & Co.	93	2	5 6	4	3 6	. . . .	13 0 0
Rothwell & Co.	93	2	5 6	4	3 6	. . . .	13 0 0
Rothwell & Co.	93	2	5 6	4	3 6		13 0 0
Rt. Stephenson & Co. (154) .		2	4 6	4	$\left\{ \begin{array}{l} 4 \ 6 \\ 3 \ 2 \end{array} \right.$		
Rt. Stephenson & Co. (208) .		2	5 6	4	3 6 $\frac{3}{4}$		
Rt. Stephenson & Co. (209) .		2	5 6	4	3 6		
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	13 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	13 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	13 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	13 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	13 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	13 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	13 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	12 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	12 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	12 5 0
Sharp, Roberts, & Co. . . .	25	2	5 6	4	3 6	. . . .	12 5 0

Rt. Stephenson & Co.	2	ft. ins. 6 0	4	ft. ins. 4 0	tons. cwt. qrs.	tons. cwt. qrs.
Rt. Stephenson & Co. (206) .	2	6 0	4	$\left\{ \begin{array}{l} 4 \ 0 \\ 4 \ 6 \end{array} \right.$		
Rt. Stephenson & Co. (249) 41	2	6 0	4	4 0		
Rt. Stephenson & Co. (250) 97	2	6 0	4	4 0		
Rt. Stephenson & Co. (255) 41	2	6 0	4	4 0		

AY.

DIMENSIONS OF FIRE-BOX.		DIMENSIONS OF CHIMNEY.		SIZE.		WHEELS.				WEIGHT OF ENGINE.	
Height above the Grate Bars.	Area exposed to radiating Caloric.	Diameter in Inches.	Height in Feet.	Sectional Area in Inches.	Of Blast Pipe.	Driving.		Carrying.		In Working Trim.	Empty.
						No.	Diameter in Feet.	No.	Diameter in Feet.		
Inches.	sq. ft.		ft. ins.				ft. ins.		ft. ins.	tons. cwt. qrs.	tons. cwt. qrs.
45	47.30	..	..	..	..	2	4 6	4	$\begin{cases} 4 & 6 \\ 3 & 0 \end{cases}$		
44	47.35	..	..	..	..	2	4 6	4	$\begin{cases} 4 & 6 \\ 3 & 0 \end{cases}$		
48	53.52	..	..	..	..	2	6 0	4	3 6		
33	32.78	12 $\frac{1}{2}$	14 0	5.61	..	2	5 0	2	3 6	7 7 0	6 11 2
33	32.78	12 $\frac{1}{2}$	14 0	5.61	..	2	5 0	2	3 6	7 7 0	6 11 2
39 $\frac{5}{8}$	43.14	12 $\frac{3}{4}$	13 1	8.08	..	2	5 0	4	3 6		
38	44.18	12 $\frac{7}{8}$	..	8.76	..	2	4 6	4	$\begin{cases} 4 & 6 \\ 3 & 6 \end{cases}$		
39	43.76	15 $\frac{5}{8}$	13 6	8.08	..	2	6 0	4	4 0		
39	43.76	15 $\frac{5}{8}$	13 6	8.08	..	2	6 0	4	4 0		
39	43.76	15 $\frac{5}{8}$	13 6	8.08	..	2	6 0	4	4 0		
39 $\frac{5}{8}$	46.81	12 $\frac{7}{8}$	13 6	10.00	..	2	6 0	4	4 0		
40 $\frac{1}{2}$	47.61	14	..	..	..	2	5 0	4	3 6		
36	46.62	14	5 10	10.56	..	2	5 6	4	3 6	....	12 10 0
36	46.62	14	5 10	10.56	..	2	5 6	4	3 6	....	12 10 0
36 $\frac{5}{8}$	43.37	13 $\frac{1}{4}$	14 6 $\frac{3}{4}$	9.21	4.41	2	5 0	4	3 6		
36 $\frac{5}{8}$	43.53	13 $\frac{1}{4}$	14 6 $\frac{3}{4}$	9.21	4.41	2	5 0	4	3 6		

struction of the Tables.—The tables consist of twenty-six columns. The *first* column contains the the maker, and, in some instances, the number of engine according to the manufacturer's own list; *d* is for the number according to the Railway Company's list; the *third*, for the name of the engine; *h*, for the year in which it was manufactured; the *fifth* and *sixth*, for the diameter of cylinders and stroke in inches respectively; the *seventh* and *eighth*, for the diameter of the boiler in inches, and *i* in feet and decimal parts of a foot; the *ninth*, *tenth*, *eleventh*, and *twelfth* columns contain the of the tubes in inches, their length in feet and decimals, their number, and the area exposed to the of heated air in superficial feet and decimals; the *thirteenth*, *fourteenth*, *fifteenth*, and *sixteenth*, he dimensions of the fire-box in inches, and the area exposed to radiating caloric in superficial feet nals; the *seventeenth* and *eighteenth* are for the diameter of chimney in inches, and the height in feet s. In some of the tables, the height of chimney given is from the rails, and in others from the top of ox; this will be readily seen in each case. The *nineteenth* contains the sectional area in superficial d decimals of the steam-passage; the *twentieth*, the sectional area, in superficial inches and decimals, ast-pipe; the *twenty-first*, *twenty-second*, *twenty-third*, and *twenty-fourth*, contain the number and of wheels in feet and inches; and, lastly, the *twenty-fifth* and *twenty-sixth* are for the gross and net respectively of the locomotive engine in tons, cwts., and quarters.

calculating the area of the tubes the external diameter has been taken throughout, as we found this mode generally adopted by other engineers. The actual surface of fire-box exposed to radiating obtained by adding together the area of sides and top, the height being taken from the top of the s, and deducting the collective areas of furnace-door and tube-ends.

STANDING ORDERS OF THE HOUSE OF COMMONS

Relative to Railway-Bills,

AS AGREED TO ON THE 10TH DAY OF AUGUST, 1840.

. The word "railway" is substituted throughout the following pages for the word "private."

THAT a committee be appointed at the commencement of every session, consisting of forty-two members, of whom five shall be a quorum in opposed cases, and three a quorum in unopposed cases; to which shall be referred all petitions for railway bills, and such committee shall be denominated "The Select Committee on Petitions for Railway Bills."

That the said committee shall have leave to divide themselves into sub-committees, each consisting of seven members at the least, and to make regulations for the transaction of business.

That a committee be appointed at the commencement of every session, consisting of fifteen members (not being members of the select committee on petitions for railway bills), of whom five shall be a quorum; and such committee shall be denominated "The Select Committee on Standing Orders."

That a committee be appointed at the commencement of every session, consisting of the chairman of the select committee on standing orders, and of the chairmen of the committee and of the sub-committees on petitions for railway bills, of whom three shall be a quorum; and such committee shall be denominated "The Committee of Selection."

That the committee on every "opposed railway bill" shall consist of the members on the Speaker's list of that county or division of the county to which the bill specially relates, and of such number of "selected members" not locally interested in the bill in progress, and in such proportion, as the circumstances of each case shall in the judgment of the committee of selection require; of which committee five (including the quorum of selected members) shall be a quorum.

That the committee on every "unopposed railway bill" which shall have originated in this House, shall consist of the chairman of the committee of

ways and means, together with the members ordered to prepare and bring in the bill; and that the committee on every "unopposed private bill" which shall have been brought from the House of Lords, shall consist of the chairman of the committee of ways and means, and of not less than two other members to be named by the committee of selection; and that the chairman of the committee of ways and means shall be the chairman of the committee on every "unopposed private bill;" and that such chairman, and one of such other members, shall be the quorum required to be present during the whole progress of the bill through such committee.

That after any committee on a railway bill shall have been formed, no members shall be added thereto, unless by special order of the House.

DUTY OF THE SELECT COMMITTEE ON PETITIONS FOR RAILWAY BILLS.

That the compliance with the following standing orders shall be proved before one of the sub-committees of the select committee on petitions for railway bills, and any parties shall be at liberty to appear and be heard, by themselves, their agents, and witnesses, upon any petition which may be referred to such committee, complaining of a non-compliance with the standing orders, provided the matter complained of be specifically stated in such petition, and that such petition be presented three clear days before the first meeting of such sub-committee.

That in the case of any application for a railway bill relating to *Scotland*, the committee may admit proof of the compliance with the standing orders of this House, on the production of affidavits sworn before any sheriff-depute or his substitute there, whose certificate shall be admitted as evidence of

such proof having been made, unless the committee shall require further evidence.

That in the case of any application for a railway bill relating to *Ireland*, the committee may admit proof of the compliance with the standing orders of the House, on the production of affidavits sworn before any judge or assistant barrister of that part of the United Kingdom, whose certificate shall be admitted as evidence of such proof having been made, unless the committee shall require further evidence.

That when the sub-committee shall report to the House that the standing orders have not been complied with, they do report the facts upon which their decision is founded, and any special circumstances connected with the case.

That all *petitions applying for leave to dispense with* any of the *sessional orders* of the House relating to railway bills, be referred to the select committee on petitions for railway bills, and that they do report to the House whether such orders ought or ought not to be dispensed with.

That notices shall be given in all cases where application is intended to be made for leave to bring in a railway bill.

Bills relating to railways are included in the second and third classes of private bills.

2d Class. For making, maintaining, varying, extending, or enlarging any railway.

3d Class. For continuing or amending any former railway act, where no further work than such as was authorised by any former act is proposed to be made.

That notices shall be published in three successive weeks in the months of October and November, or either of them (and in the case of such railway bills as are included in the second class, in lieu of those months, twice in the month of February, and twice in the month of March), immediately preceding the session of Parliament in which application for the bill shall be made, in the London, Edinburgh, or Dublin Gazette, as the case may be, and in some one and the same newspaper of the county in which the city, town, or lands to which such bill relates shall be situate; or if there is no newspaper published therein, then in the newspaper of some county adjoining or near thereto; or if such bill does not relate to any particular city, town, or lands, in the London, Edinburgh, or Dublin Gazette only, as the case may be; and that all notices required to be

inserted in the London, Edinburgh, or Dublin Gazette, shall be delivered at the office of the gazette in which the insertion is required to be made, during the usual office-hours, at least two clear days previous to the publication of the gazette, and that the receipt of the printer for such notice shall be proof of its due delivery.

That if it be the *intention of the parties* applying for leave to bring in a railway bill, *to levy any tolls, rates, or duties*, or to alter any existing tolls, rates, or duties, the *notices shall specify such intention*.

That on or before the 31st day of December immediately preceding the application for a bill by which any lands or houses are intended to be taken, or an extension of the time granted by any former act for that purpose, is sought for, application in writing, and in cases of bills included in the second class, in the form appended hereto, be made to the owners or reputed owners, lessees or reputed lessees, and occupiers, either by delivering the same personally, or by leaving the same at their usual place of abode, or in their absence from the United Kingdom, with their agents respectively; of which application having been duly made, the production of a written acknowledgment by the party applied to of the receipt of such application, shall be sufficient evidence, in the absence of other proof, of the same having been duly delivered or left as aforesaid; and that separate lists be made of the names of such owners, lessees and occupiers, distinguishing which of them have assented, dissented, or are neuter in respect thereto.

Orders specially relating to Railway Bills of the 2d Class.

That in cases of bills included in the 2d class, all *notices shall contain the names of the parishes, townships, and extra-parochial places*, from, in, through, or into which the work is intended to be made, maintained, varied, extended, or enlarged, and *shall state the time and place of deposit of the plans, sections, and books of reference respectively*, with the clerks of the peace, parish clerks, schoolmasters, town clerks, and postmasters, as the case may be.

That a *plan*, and also a duplicate of such plan, on a *scale* of not less than *four inches to a mile*, be deposited for public inspection at the office of the clerk of the peace for every county, riding, or division in England or Ireland, or in the office of the principal sheriff-clerk of every county in Scotland, in or through which the work is proposed to be made, varied,

extended, or enlarged, on or before the first day of March immediately preceding the session of parliament in which application for the bill shall be made; which plans shall describe the line or situation of the whole of the work, and the lands in or through which it is to be made, maintained, varied, extended, or enlarged, or through which every communication to or from the work shall be made; together with a book of reference containing the names of the owners or reputed owners, lessees or reputed lessees, and occupiers of such lands respectively.

That where it is the intention of the parties to apply for powers to make any *lateral deviation* from the line of the proposed railway, the limits of such deviation *shall be defined upon the plan*, and all lands included within such limits shall be marked thereon; and that in all cases, *an additional plan of any building, yard, court-yard, or land* within the curtilage of any building, or of any ground cultivated as a garden, either on the original line or included within the limits of the said deviation, shall be laid down on the said plan, or on the additional plan deposited therewith, upon a *scale* of not less than a *quarter of an inch* to every 100 feet.

That the *section* shall be drawn to the *same horizontal scale as the plan*, and to a *vertical scale* of not less than *one inch to every 100 feet*, and shall shew the surface of the ground marked on the plan, and the intended level of the proposed work, and a *datum horizontal line*, which shall be the same throughout the whole length of the work, or any branch thereof respectively, and shall be referred to some fixed point stated in writing on the section, near either of the termini.

That the clerks of the peace or sheriff-clerks, or their respective deputies, do make a memorial in writing upon the plans, sections, and books of reference so deposited with them, denoting the time at which the same were lodged in their respective offices, and do at all seasonable hours of the day permit any person to view and examine one of the same, and to make copies or extracts therefrom; and that one of the two plans and sections so deposited be sealed up and retained in the possession of the clerk of the peace or sheriff-clerk, until called for by order of one of the two Houses of Parliament.

That on or before the first day of April, where the previous deposits with the clerks of the peace or sheriff-clerks are required on the first day of March, a *copy* of so much of the *said plans and sections as relates to each parish* in or through which

the work is intended to be made, maintained, varied, extended, or enlarged, *together with a book of reference thereto, shall be deposited with the parish-clerk of each such parish in England, the schoolmaster of each such parish in Scotland (or in royal burghs with the town-clerk), and the postmaster of the post-town in or nearest to such parish in Ireland*, according to the act 1 Vict. cap. 83, appended hereto.

That on or before the 31st day of December (and on or before the 1st day of April, where the previous deposits with the clerks of the peace or sheriff-clerks are required on the 1st day of March), a *copy* of the said *plans, sections, and books of reference, shall be deposited in the Private Bill Office of this House*.

That an *estimate* of the *expense* be made and signed by the person making the same, and that a subscription be entered into under a contract, made as hereinafter described, to three-fourths the amount of the estimate.

That in cases where the work is to be made by means of funds, or out of money to be raised upon the credit of present surplus revenue, under the control of the directors of any existing railway, a declaration stating those facts, and setting forth the particulars of such control, and the nature and amount of such funds or surplus revenue, and given under the common seal of the company, or under the hand of some authorised officer of such directors, trustees, or commissioners, may be substituted in lieu of the subscription contract, and in addition to the estimate of the expense.

That all *subscription contracts shall contain the christian and surname, description, and place of abode of every subscriber*; his signature to the amount of his subscription, with the amount which he has paid up; and the name of the party witnessing such signature, and the date of the same respectively; and that it be proved to the satisfaction of the committee on petitions, that *a sum equal to one-tenth part of the amount subscribed* has been deposited with the *Court of Exchequer in England*, if the work is intended to be done in England, or with the *Court of Exchequer either in England or Scotland*, if such work is intended to be done in Scotland, and with the *Court of Chancery in Ireland*, if such work is intended to be done in Ireland; and that not less than three-fourths in number of the subscribers shall have paid up their shares of such deposit, according to the act 1st and 2d Vict. cap. 117, appended hereto.

That no subscription-contract shall be valid, unless it be entered into subsequent to the close of the

session of Parliament previous to that in which application is made for leave to bring in the bill to which it relates, and unless the parties subscribing to it bind themselves, their heirs, executors, and administrators, for the payment of the money so subscribed.

That previous to the presentation of a petition for the bill, copies of the *subscription-contract*, with the names of the subscribers arranged in alphabetical order, and the amount of the deposit respectively paid up by each such subscriber, or where a declaration and estimate of the probable amount of rates and duties are substituted in lieu of a subscription-contract, copies of such declaration, *or of such declaration and estimate*, be *printed at the expense of the promoters of the bill*, and be delivered at the *Vote-office*, for the use of the Members of the House.

That before any application is made to the House for a bill, whereby any part of a *work* authorised by any former act is *intended to be relinquished*, notice in writing of such bill be given to the owners or reputed owners and occupiers of the lands in which the part of the said work intended to be thereby relinquished is situate.

That in all cases where it is proposed to make, vary, extend, or enlarge any railway, the plan shall exhibit thereon the height of the several embankments, and the depth of the several cuttings respectively, on a scale specified thereon.

That in every section of a railway, *the line marked thereon shall correspond with the upper surface of the rails*.

That a *vertical measure* from the datum line to the line of the railway *shall be marked in feet and inches at each change of the gradient or inclination*, and that the proportion or *rate of inclination* between each such change shall *also be marked*.

That the *height of the railway over or under the surface of every turnpike-road, public carriage-road, navigable river, canal, or railway, or junction with a railway*, shall be *marked in figures at every crossing thereof*; and if there shall be no such crossing in every half mile, then the height over or under the surface of the ground shall be marked once in that space; and if any alteration in the present level or rate of inclination of any turnpike-road, carriage-road, or railway, be intended, then the same shall be stated on the said section.

That where *tunnelling* as a substitute for open cutting, or *arching* as a substitute for solid embankment, be intended, the same *shall be marked both on the plan and section*.

That *parties desiring to deviate from the line of any railway*, of which the plans, sections, and books of reference shall have been deposited, and for which the notices shall have been given as before directed, *shall be permitted so to do, provided no one deviation shall exceed one mile in length*, and provided a plan and section, as before described, of such deviation, together with a book of reference thereto, shall be deposited with the clerk of the peace of every county, riding, or division in England or Ireland, or in the office of the principal sheriff-clerk of every county in Scotland, in which such deviation is proposed to be made, and a plan and section so far as relates to each parish, together with a book of reference thereto, with the parish-clerks of each such parish in England, the schoolmaster of each such parish in Scotland (or in royal burghs with the town-clerk), and the postmaster of the post-town in or nearest to each such parish in Ireland, in which such deviation is proposed to be made, on or before the 30th day of November immediately preceding the application to Parliament; and that the intention to make such deviation shall be published in manner before directed, in three successive weeks in the months of October and November, or either of them; and that on or before the 31st day of December immediately preceding such application to Parliament, application in writing be made to the owners or reputed owners, lessees or reputed lessees, and occupiers of the lands through which such deviation is proposed to be made, either by delivering the same personally, or by leaving the same at their usual place of abode, or, in their absence from the United Kingdom, with their agents respectively; and that separate lists be made of such owners, lessees, and occupiers, distinguishing which of them have assented, dissented, or are neuter in respect thereto.

That *parties desiring to renew any application to Parliament in respect of any railway*, of which the plans, sections, and books of reference shall have been deposited, and for which the notices shall have been given as before directed, *shall be permitted so to do in the session next ensuing* that in which such application to Parliament was made, provided a plan and section, as before described, of such railway, together with a book of reference thereto, shall be deposited with the clerk of the peace of every county, riding, or division in England or Ireland, or in the office of the principal sheriff-clerk of every county in Scotland, in or through which such railway is proposed to be made; and a plan and section, as

before described, so far as relates to each parish, together with a book of reference thereto, with the parish-clerks of each such parish in England, the schoolmaster of each such parish in Scotland (or in royal burghs with the town-clerk), and the postmaster of the post-town in or nearest to each such parish in Ireland, through which such railway is proposed to be made, on or before the 30th day of November immediately preceding such renewed application to Parliament; and that the intention to make such application shall be published in manner before directed, in the months of October and November, or either of them; and that on or before the 31st day of December immediately preceding such renewed application to Parliament, application in writing be made to the owners or reputed owners, lessees or reputed lessees, and occupiers of the lands through which any such railway is proposed to be made, either by delivering the same personally, or by leaving the same at their usual place of abode, or, in their absence from the United Kingdom, with their agents respectively; and that separate lists be made of such owners, lessees, and occupiers, distinguishing which of them have assented, dissented, or are neuter in respect thereto.

That in every case of non-compliance with the standing orders, the select committee on standing orders shall determine whether the standing orders ought or ought not to be dispensed with, and report the same to the House accordingly.

That the committee of selection shall select and add to the Speaker's list such number of members not locally interested in the bill in progress, and in such proportion, as the circumstances of each case shall in their judgment require; such members making declaration of their willingness to serve on the committee.

That the committee of selection shall in each case direct what number of the members (not locally interested in the bill) selected and added to the list by them, shall be a quorum of such members.

That as soon as possible after the sitting of the committee of selection, at which the name of any member shall have been added to any list prepared under the direction of Mr. Speaker, the clerk attending the committee of selection shall give notice to each such member of his name having been so added, and of the time when the committee on the bill shall have been appointed to meet.

That all railway bills, after having been read the second time and committed, shall be referred to the committee of selection.

That every opposed railway bill shall be referred by the committee of selection to the Speaker's list of that county or division of the county to which the bill specially relates, and to such number of selected members not locally interested in the bill in progress, and in such proportion, as the circumstances of each case shall in the judgment of the committee of selection require, and that five members, including the quorum of selected members, be the quorum of a committee on such bill.

That there be seven clear days between the second reading of every railway bill, and the sitting of the committee thereupon, and that, subject to this regulation, the time for holding the first sitting of every committee on a railway bill, shall be fixed by the committee of selection, but in the case of unopposed railway bills, after communication with the members who are to form the committee on such bill; and no postponement of such first sitting shall take place, unless such postponement, and the duration of it, shall have been sanctioned by the committee of selection.

That the names of the members attending each committee be entered by the clerk on the minutes of the committee; and if any division shall take place in the committee, the clerk do take down the names of members voting in any such division, distinguishing on which side of the question they respectively vote, and that such lists be given in with the report to the House.

That no member of the committee shall be entitled to attend or vote unless he shall have previously made and signed a declaration of his willingness to serve on the committee on the bill, according to the form required by the standing orders of the House.

That the following shall be the several forms of declaration which every member shall sign before he shall be entitled to attend or vote on any committee on any railway bill:—

DECLARATION of a member whose name is on the list prepared under the direction of Mr. Speaker for

The undersigned, being one of the members whose name is on the list prepared under the direction of Mr. Speaker, to which list the bill for has been committed, hereby declares, That he is willing to serve on such committee; and that he will never vote on any question which may arise without having duly heard and attended to the evidence relating thereto.

Memorandum.—The declaration, signed as aforesaid, must be delivered to the clerk of the committee on the bill before the committee shall proceed to appoint a chairman; otherwise the member signing the same shall not be entitled to attend or vote.

The DECLARATION of a member whose name has been added to the list prepared under the direction of Mr. Speaker by the committee of selection, his constituents having no local interest in the bill for

The undersigned, being one of the members selected and added to the list by the committee of selection, to which list the bill for has been committed, hereby declares, That his constituents have no local interest, and that he has no personal interest in such bill; and that he is willing to serve on such committee; and that he will never vote on any question which may arise without having duly heard and attended to the evidence relating thereto.

Memorandum.—The declaration, signed as aforesaid, must be delivered to the clerk of the committee on the bill before the committee shall proceed to appoint a chairman, otherwise the member signing the same shall not be entitled to attend or vote.

That the committee-clerk shall furnish to each member appointed to serve on a committee on a railway bill, who shall apply for the same, a form of one of the above declarations, according to the class to which the member may belong; and that such application shall be made to the committee-clerk, either in the committee-clerks' office, previous to the time when the committee shall have been appointed to meet, or in the committee-room, previous to the door thereof being locked, as hereinafter directed.

That so soon *after the expiration of ten minutes*, and not sooner, *after the time appointed for the first sitting of a committee on an opposed railway bill*, as there shall be present at least five members appointed and duly qualified to serve on such committee (including a quorum of selected members), *the clerk of such committee shall give notice that a sufficient number of members to proceed to business is present*, and the clerk shall direct the messenger in attendance on the committee to clear the room of all strangers, and to lock the door of the committee-room; the members shall then proceed to appoint a chairman; and that no member shall be entitled to attend or vote on such committee who shall not have duly delivered

his declaration to the clerk previously to the time when the door shall have been so locked.

That *no committee* on a railway bill *shall, without leave of the House, proceed to business*, or continue their inquiry or deliberations, *unless a quorum of the selected members shall be present*; and that if at any time during the sitting of the said committee a quorum of the selected members shall not be present, the chairman of the committee shall suspend the proceedings of such committee until such quorum shall be present; and that if at the expiration of one hour from the time fixed for the meeting of the committee, or from the time when the chairman shall so have suspended the proceedings of such committee, a quorum of the selected members shall not be present, the chairman shall adjourn the committee until twelve of the clock of the day on which the House shall next meet, and report forthwith to the House the circumstances of the case; but the committee may (if they shall think fit), previous to such adjournment, resolve that the bill shall be reported in the state in which it was at the time that the proceedings were so suspended, although a quorum of selected members shall not be present at the time of coming to such resolution.

That *if at any time* after the committee on a bill shall have been formed, *a quorum of members* required by the standing orders *cannot attend* in consequence of any of the members who shall have duly qualified to serve on such committee having become incompetent to continue such service by having been placed on an election committee, or by death or otherwise, the *chairman shall report* the circumstances of the case to the House, in order that such measures may be taken by the House as shall enable the members still remaining on the committee to proceed with the business referred to such committee, or as the exigency of the case may require.

That *the committee shall not have power to examine into the compliance or non-compliance with such standing orders* as are directed to be proved before the select committee on petitions for private bills, *unless by special order of the House*.

That *no petition against a railway bill be referred to the committee on such bill, unless it shall distinctly specify the ground on which the petitioner or petitioners object* to any of the provisions thereof; and that the petitioners be only heard on such grounds so stated; and if it shall appear to the said committee that such grounds are not specified with sufficient accuracy, the committee may direct that there

be given in to the committee a more specific statement, in writing, and limited to such grounds of objection so inaccurately specified.

That *no petitioners against any railway bill shall be heard* before the committee on the bill, *unless the petition shall have been presented to this House three clear days before the day appointed for the first meeting* of such committee, unless the petitioners shall complain of any matter which may have arisen during the progress of the bill before the said committee.

That the *chairman of the committee do sign*, with his name at length, *a printed copy of the bill*, to be called the Committee-Bill, on which the amendments are to be fairly written, and also sign with the initials of his name the several clauses added in the committee.

That *every plan and book of reference* thereto, *which shall be produced in evidence* before the committee upon any railway bill, whether the same shall have been previously lodged in the Private Bill Office, or not, *shall be signed by the chairman of such committee*, with his name at length; and he shall also mark with the initials of his name every alteration of such plan and book of reference which shall be agreed upon by the said committee; and every such plan and book of reference shall thereafter be deposited in the Private Bill Office.

That in the case of *any railway bill relating to Scotland*, the committee may admit proof of the compliance with the standing orders of this House, and of the consent of parties concerned in interest in such private bill, on the production of affidavits sworn before any sheriff-depute or his substitute there, whose certificate shall be admitted as evidence of such proof having been made, unless the committee shall require further evidence.

That in the case of *any railway bill relating to Ireland*, the committee may admit proof of the compliance with the standing orders of the House, and of the consent of parties concerned in interest in such railway bill, on the production of affidavits sworn before any judge or assistant barrister of that part of the United Kingdom, whose certificate shall be admitted as evidence of such proof having been made, unless the committee shall require further evidence.

That in all other instances the committee may admit proof of the consents of parties concerned or interested in any private bill, on the production of certificates in writing of such parties, whose signature to such certificate shall be proved by one or more witnesses,

unless the committee shall require further evidence.

That in all bills presented to the House for carrying on any railway by means of a company, *provision be made for compelling persons who have subscribed any money towards carrying any such railway into execution, to make payment of the sums severally subscribed by them, and also to oblige the company to take security from their treasurer, receiver, or collector, for the faithful execution of his office.*

That in all railway bills, whereby any parties are authorised to levy fees, tolls, or other rate or charge, a *clause be inserted, enacting, that an annual account, in abstract, be prepared of the total receipts and expenditure of all funds levied under such bill for the past year, under the several distinct heads of receipts and expenditure, with a statement of the balance of the said account, duly audited and certified by the directors, managers, or auditors thereof; and that a copy of such annual account be transmitted, free of charge, to the clerk of the peace (or in Scotland to the sheriff-clerk) for the county, or to the clerk of the city or borough within which the chief office for the management of such funds shall be situated, on or before the 31st day of January in each year, under a sufficient penalty for not preparing and sending in the said account, to be levied by summary process; the said account to be open at all seasonable hours to the inspection of the public upon payment of a fee.*

That *where the level of any road shall be altered in making any railway, the ascent of any turnpike-road shall not be more than one foot in 30 feet; and of any other public carriage-road not more than one foot in 20 feet; and that a good and sufficient fence, of four feet high at the least, shall be made on each side of every bridge which shall be erected.*

That the *chairman* of the committee, upon the report of every private bill, *do acquaint the House that the allegations of the bill have been examined; and whether the parties concerned have given their consent (where such consent is required by the standing orders), to the satisfaction of the committee.*

That the *minutes of the committee* on every private bill be brought up and *laid on the table of the House*, with the report of the bill.

That in the case of a railway bill, *no company shall be authorised to raise, by loan or mortgage, a larger sum than one-third of their capital; and that, until fifty per cent on the whole of the capital shall have been paid up, it shall not be in the power of*

the company *to raise any money by loan or mortgage.*

That no railway whereon carriages are propelled by steam shall be made across any turnpike-road or other public carriage-way on the level, unless the committee on the bill report that such a restriction ought not to be enforced, with the reasons and facts upon which their opinion is founded.

That the committee report specially :—

The proposed capital of the company formed for the execution of the project, and the amount of any loans which they may be empowered to raise by the bill.

The amount of shares subscribed for, and the deposits paid thereon.

The names and places of residence of the directors or provisional committee, with the amount of shares taken by each.

The number of shareholders who may be considered as having a local interest in the line, and the amount of capital subscribed for by them.

The number of other parties, and the capital taken by them.

*The number of shareholders subscribing for 2000*l.* and upwards, with their names and residences, and the amount for which they have subscribed.*

The sufficiency or insufficiency for agricultural, commercial, manufacturing, or other purposes, of the present means of conveyance, and of communication between the proposed termini, stating the present amount of traffic by land or water, the average charges made for passengers and goods, and time occupied.

The number of passengers, and the weight and description of the goods expected upon the proposed railway.

The amount of income expected to arise from the conveyance of passengers and goods, and in what proportion ; stating also, generally, the description of goods from which the largest revenue is anticipated.

Whether the proposed railway be a complete and integral line between the termini specified, or a part of a more extended plan now in contemplation, and likely to be hereafter submitted to Parliament, and to what extent the calculations of remuneration depend on such contemplated extension of the line.

Whether any, and what, competing lines of railway there are existing, and whether any, and what, are in progress or contemplation ; and to state, so far as circumstances will permit, in what respects the proposed line is superior or inferior to the other

lines ; but that no line of railway be deemed a competing line in contemplation, unless the plan, section, and book of reference for the same shall have been deposited with the clerks of the peace and in the private bill-office respectively, as required by the standing orders.

What planes on the railway are proposed to be worked, either by assistant engines, stationary, or locomotive, with the respective lengths and inclinations of such planes.

Any peculiar engineering difficulties in the proposed line, and the manner in which it is intended they should be overcome.

The length, breadth, and height, and means of ventilation, of any proposed tunnels, and whether the strata through which they are to pass are favourable or otherwise.

Whether in the lines proposed the gradients and curves are generally favourable or otherwise, and the steepest gradient, exclusive of the inclined planes above referred to, and the smallest radius of a curve.

The length of the main line of the proposed railway, and of its branches respectively.

Whether it be intended that the railway should pass on a level any turnpike-road or highway, and if so, to call the particular attention of the House to that circumstance.

The amount of the estimates of the cost or other expenses to be incurred up to the time of the completion of the railway, and whether they appear to be supported by evidence, and to be fully adequate for the purpose.

The estimated charge of the annual expenses of the railway when completed, and how far the calculations on which the charge is estimated, have been sufficiently proved.

Whether the calculations proved in evidence before the committee have satisfactorily established that the revenue is likely to be sufficient to support the annual charges of the maintenance of the railway, and still allow profit to the projectors.

The number of assents, dissents, and neuters, upon the line, and the length and amount of property belonging to each class traversed by the said railway, distinguishing owners from occupiers ; and in the case of any bill to vary the original line, the above particulars with reference to such parties only as may be affected by the proposed deviation.

The name of each engineer examined in support of the bill, and of any examined in opposition to it.

The main allegations of every petition which may

have been referred to the committee in opposition to the preamble of the bill, or to any of its clauses; and whether the allegations have been considered by the committee, and if not considered, the cause of their not having been so.

And the committee shall also report generally as to the fitness, in an engineering point of view, of the projected line of railway, and any circumstances which, in the opinion of the committee, it is desirable the House should be informed of.

Clauses to be inserted in Railway-bills.

“ And be it further enacted, that it shall not be lawful for the said company to proceed in the execution of the said railway hereinbefore authorised to be made, unless the said company shall have, previously to the commencement of such work, deposited with the clerk of the peace of the several counties in England or Ireland, and in the office of the principal sheriff-clerk in every county in Scotland, in or through which the said railway hereby authorised to be made is intended to pass, a plan and section of all such alterations from the original plan and section as shall have been approved of by Parliament, on the same scale and containing the same particulars as the original plan and section of the railway; and also with the clerks of the several parishes in England, the schoolmasters of the several parishes in Scotland (or in royal burghs with the town-clerk), and the postmasters of the post towns in or nearest to such parishes in Ireland in or through which such alterations shall have been authorised to be made, copies or extracts of or from such plans and sections as shall relate to such parishes respectively; and all persons interested shall have liberty to inspect and make extracts from or copies of the said plans and sections, or extracts or copies thereof, paying to the officer having the custody of such plan and section, or of such extract or copy, the sum of one shilling for every such inspection, and after the rate of sixpence for every one hundred words copied therefrom.”

“ And be it further enacted, that in making the said railway it shall not be lawful for the said company to deviate from the levels of the said railway as referred to the common datum line described on the section so approved of by Parliament, and as marked on the same, to any extent exceeding in any place five feet, or in passing through towns two feet, without the consent of the owners, lessees, and occupiers of the land in, through, or over which such

deviation is intended to be made; or in case any street or public carriage-road shall be affected by such deviation, then the same shall not be made without the consent of the trustees or commissioners, or, if there be no such trustees or commissioners, without the consent of two or more justices of the peace in petty sessions assembled for that purpose, and acting for the district in which such street or public carriage-road may be situate, or without the consent of the commissioners for any public sewers, or the proprietors of any canal or navigation affected by such deviation; and that no increase in the inclination or gradients of the said railway, as denoted by the said section, shall be made in any place to an extent exceeding the rate of three feet per mile; and where in any place it is intended to carry the railway on an arch or arches, as marked on the said plan or section, the same shall be made accordingly; and where a tunnel is marked on the said plan or section as intended to be made at any place, the same shall be made accordingly, unless the owners, lessees, and occupiers of the land in or through which such tunnel is intended to be made, shall consent that the same shall not be so made: provided, nevertheless, that it shall be lawful for the said company, with such consent as aforesaid, and not otherwise, to make a tunnel or an arch or arches as aforesaid not marked on the said plan or section, so that no such tunnel shall be of greater length than two hundred yards, and that no two tunnels be at a less distance from each other than one hundred yards measured on the line of the railway. Provided always, that notice of every petty sessions to be holden for the purpose of obtaining such consent as aforesaid shall, fourteen days previous to the holding of such petty sessions, be given in some newspaper circulating in the county, and also to be affixed upon the church-door of the parish in which such deviation or alteration is intended to be made, or if there be no church, some other place to which notices are usually affixed; and provided also, that for the purpose of consenting to any such deviation from the said sections, and to any tunneling or arching as aforesaid, the word ‘ owners ’ shall be deemed and taken to mean such persons as are herein capacitated to agree for the sale of and to convey land for the making of the said railway; and the consent of such persons, with or without the consent of any other persons interested as owners in the said lands, shall be deemed and taken to be sufficient for such purposes.”

"And be it further enacted, that it shall not be lawful to diminish the radius of any curve as described on the plan deposited with the clerk of the peace, or principal sheriff-clerk, unless such radius exceed one mile, nor to diminish it in any such case so that it shall become less than one mile, nor to diminish any greater radius by more than a quarter of a mile, unless where it exceeds two miles, or by more than half a mile, unless where it exceeds three miles on the said plan."

That every committee to whom any railway bill shall have been referred shall report the bill to the House, whether such committee shall or shall not have agreed to the preamble, or gone through the several clauses, or any of them.

That *every unopposed railway bill*, and which shall have originated in this House, *shall be referred* by the committee of selection *to the chairman of the committee of ways and means*, together with the members ordered to prepare and bring in the bill; and every unopposed railway bill which shall have been brought from the House of Lords, shall be referred by the committee of selection to the chairman of the committee of ways and means, together with not less than two other members, to be named by the committee of selection; and that the chairman of the committee of ways and means shall be the chairman of the committee on every unopposed railway bill; and that such chairman and one of such other members shall be the quorum required to be present during the whole progress of the bill through such committee.

That such *chairman* shall be at liberty, at any period after an unopposed railway bill shall have been so referred to him and such other members as aforesaid, and before the report of such bill, *to report his opinion to the House, if he shall think fit*, that such bill should be treated as an opposed railway bill; in which case such bill shall be again referred to the committee of selection, and shall be dealt with by them as an opposed railway bill.

That *a filled-up bill*, signed by the agent for the bill, as proposed to be submitted to the committee, *be laid* by him *before such chairman*, at the time of giving notice of the meeting of the committee on the bill, and that similar copies be also laid by the agent for the bill before the other members of the said committee three days at the least before the first meeting thereof.

PRACTICE OF THE HOUSE OF COMMONS WITH REGARD TO
RAILWAY BILLS.

That no railway bill be brought into this House, but upon a petition first presented, truly stating the case: and that such petition be signed by the parties, or some of them, who are suitors for the bill.

That all petitions for railway bills be presented within fourteen days after the first Friday in every session of Parliament.

That there be ten clear days between the day on which the petition for any railway bill relating to England shall be presented, and the day on which the sub-committee shall sit thereupon; and fifteen days, in case such bill shall relate to Scotland or Ireland.

That ten clear days' notice be given to the clerks in the Private Bill Office of the meeting of any sub-committee on a petition for a railway bill.

That no postponement of the first meeting of any sub-committee on a petition for a railway bill shall take place, unless notice be given in the Private Bill Office, one clear day before the time fixed for such meeting.

That a bill printed on paper, of a size to be determined upon by Mr. Speaker, be presented to the House, with a cover of parchment attached to it, upon which the title of the bill is to be written; and the short title of the bill, as first entered on the votes, shall be in accordance with the subject matter of the bill, and shall not be changed unless by special order of the House.

That the proposed amount of all rates, tolls, and other matters heretofore left blank in railway bills when presented to the House, be inserted in italics in the printed bills.

That all railway bills be printed; and printed copies thereof delivered to the door-keepers for the use of the members before the first reading.

That there be three clear days between the first and second reading of all railway bills.

That this House will not receive any petitions on railway bills, referring solely to the compliance or non-compliance with the standing orders of the House, subsequently to the second reading of the bills to which they respectively relate, unless in the case of those standing orders which must necessarily be taken into consideration by the committee on the bill.

That no railway bill be read a second time, until after the expiration of two calendar months from the

day the last notice shall have been given in the newspaper.

That notice, in writing, of the day proposed for the second reading of every railway bill, be given, by the agent soliciting the bill, to the clerks in the Private Bill Office, three clear days before such second reading.

That a brieve of every railway bill be prepared under the direction of Mr. Speaker, and that such brieve shall contain a statement of the object of the bill and a summary of the proposed enactments, and shall state any variation from the general law which will be effected by the bill.

Second Reading of Bill.

That no railway bill be read a second time until three clear days after a brieve thereof shall have been laid on the table of this House, and have been printed.

That no railway bill, or clause, for the particular interest or benefit of any person or persons, county or counties, corporation or corporations, or body or bodies of people, be read a second time, unless fees be paid for the same.

That all railway bills, after having been read a second time and committed, shall be referred to the committee of selection.

That there be seven clear days between the second reading of every railway bill, and the sitting of the committee thereupon.

That notice of the day and hour on which the committee on the bill is appointed to meet be given in writing seven clear days before the time fixed for such meeting, by the agent soliciting the bill, to the clerks in the Private Bill Office, and that all committee proceedings, of which such notice shall not have been given, be void.

That no petitioners against any railway bill shall be heard before the committee on the bill, unless the petition shall have been presented to this House three clear days before the day appointed for the first meeting.

That no postponement of the first meeting of any committee on a railway bill shall take place, unless a notice, signed by the agent for the bill, and countersigned by a committee-clerk, be given in the Private Bill Office one clear day before the time fixed for such meeting; and that such notice shall be given before six of the clock in the evening of any day on which the House shall sit, or two of the clock on any day on which the House shall not sit.

That a note, in writing, of the day and hour to which each committee is adjourned, be given by the committee-clerk to the clerks in the Private Bill Office.

That the breviate of all railway bills as amended in committee shall be submitted to the chairman of the committee of ways and means, previous to the reports of such bills being taken into consideration by the House.

That a brieve of the amendments made in every committee on a bill be laid upon the table of this House, at least the day previous to that upon which the report from the committee shall be made, except when the report upon the bill may be required to lie upon the table; in which case the brieve shall be laid upon the table at least the day previous to that upon which the report shall be taken into consideration.

That every bill for making, maintaining, varying, extending, or enlarging any railway, as amended by the committee, be printed at the expense of the parties applying for the same; and be delivered to the door-keepers for the use of the members, three clear days at least before the report shall be taken into consideration.

That notice, in writing, of the day on which the bill is to be reported, be given by the agent soliciting the bill, to the clerks in the Private Bill Office, at least one clear day before the day of the report; and in all cases where reports on bills are ordered to lie on the table, notice in writing of the day on which such report is intended to be taken into consideration be given to the clerks in the Private Bill Office, at least one clear day before such report shall be taken into consideration.

That in order to afford time for the proper discussion of the reports on railway bills included in the second class, this House will upon every Tuesday proceed at five o'clock to the consideration of reports on such bills.

That there be seven clear days between the day on which every railway bill is reported, and the day upon which the report shall be taken into consideration.

That no clause shall be brought up, or any amendment made on the report, or the further consideration thereof, or on the third reading, unless the same shall have been deposited, and notice given thereof in the Private Bill Office, not later than the day previous to the same being proposed to be made.

That notice, in writing, of the day proposed for the third reading of every railway bill, be given, by

the agent soliciting the bill, to the clerks in the Private Bill Office, one clear day before such third reading.

That this House will not take into consideration the amendments made by the House of Lords to any bill sent up to them from this House, unless notice be given thereof in the Private Bill Office not later than the day previous to the same being proposed to be taken into consideration.

That no railway bill shall pass through two stages on one and the same day without the special leave of the House.

That (except in cases of urgent and pressing necessity) no motion be made to dispense with any seasonal or standing order of this House, without due notice thereof.

THE PRACTICE OF THE PRIVATE BILL OFFICE, ACCORDING TO THE STANDING ORDERS OF THE HOUSE OF COMMONS.

That a book, to be called "The Private Bill Register," be kept in a room, to be called "The Private Bill Office," in which book shall be entered by the clerks to be appointed for the business of that office, the name, description, and place of residence of the parliamentary agent in town, and of the agent in the country (if any) soliciting the bill; and all the proceedings, from the petition to the passing of the bill: such entry to specify, briefly, each day's proceeding in the House, or in any committee to which the bill or petition may be referred; the day and hour on which the committee is appointed to sit; the day and hour to which such committee may be adjourned, and the name of the committee-clerk. Such book to be open to public inspection daily, in the said office, between the hours of eleven and six.

That all plans, sections, books of reference, lists of owners and occupiers, estimates and copies of the subscription-contracts required by the standing orders of the House, be lodged in the Private Bill Office; and that the receipt thereof be acknowledged accordingly, by one of the clerks of the said office, upon the said documents, and upon the petition, before it is presented.

That ten clear days' notice be given to the clerks in the Private Bill Office of the meeting of any sub-committee on a petition for a railway bill.

That no postponement of the first meeting of any sub-committee on a petition for a railway bill shall take place, unless notice be given in the Private Bill Office one clear day before the time fixed for such meeting.

That after each railway bill has been read the first time, its name, or short title, shall be copied by the clerks of the Private Bill Office, from the clerk's minute-book of the day, into a separate book, to be called "The Examination Book:" wherein shall be noted the number of such bill, according to the priority of its being read, and the date of the day of such first reading.

That every railway bill, after it has been read the first time, and the title copied and examined for the votes, be in the custody of the clerks of the Private Bill Office, until laid upon the table for the second reading; and when committed, be taken by the proper committee-clerk into his charge, till reported.

That between the first and second readings, every such bill shall, according to its priority, be examined, with all practicable despatch, by the clerks of the Private Bill Office, as to its conformity with the rules and standing orders of the House; and the breviate thereof be compared with such bill; and the examining clerk shall, at the foot of such breviate, state, "that the bill is [or is not] prepared in due form:" and if not in due form, he shall specify the folio in which any irregularity occurs; and shall, moreover, in all cases, sign and date the breviate of such bill, with the day of such examination, and shall also enter the like date, together with his own name, in the examination-book.

That the points to which the duty of the examining clerk shall extend be the following:—viz. That the title of the bill is conformable to the order of leave; and that the subject-matter of each clause or set of clauses is sufficiently pointed out in the breviate. The form of the breviate to be such as the Speaker shall from time to time direct.

That notice in writing of the day proposed for the second reading of every railway bill be given by the agent soliciting the bill to the clerks in the Private Bill Office three clear days before such second reading.

That notice of the day and hour on which the committee on the bill is appointed to meet be given in writing seven clear days before the time fixed for such meeting, by the agent soliciting the bill, to the clerks in the Private Bill Office, and that all committee proceedings, of which such notice shall not have been given, be void.

That a filled-up bill, signed by the agent for the bill, as proposed to be submitted to the committee, be deposited in the Private Bill Office, at the time

of giving notice of the meeting of the committee; and in the case of a re-committed bill, a filled-up bill, as proposed to be submitted to the committee on re-committal, shall be deposited in the Private Bill Office, on the day that the order for such re-committal shall be made; and that all parties shall be entitled to a copy thereof, upon payment of the charges for making out amendments of such bill.

That no postponement of the first meeting of any committee on a railway bill shall take place, unless a notice signed by the agent for the bill, and countersigned by a committee-clerk, be given in at the Private Bill Office one clear day before the time fixed for such meeting; and that such notice shall be given before six of the clock in the evening of any day on which the House shall sit, or two of the clock on any day on which the House shall not sit.

That a note, in writing, of the day and hour to which each committee is adjourned, be given by the committee-clerk to the clerks in the Private Bill Office.

That notice, in writing, of the day on which the bill is to be reported, be given, by the agent soliciting the bill, to the clerks in the Private Bill Office, at least one clear day before the day of the report: and in all cases where reports on bills are ordered to lie on the table, notice in writing of the day on which such report is intended to be taken into consideration be given to the clerks in the Private Bill Office, at least one clear day before such report shall be taken into consideration.

That the committee-clerk, after the report is made out, do deliver in to the Private Bill Office a printed copy of the bill, with the written amendments made in the committee; in which bill all the clauses added by the committee shall be regularly marked in those parts of the bill wherein they are to be inserted.

That no clause shall be brought up, or any amendment made on the report, or the further consideration thereon, or on the third reading, unless the same shall have been deposited, and notice given thereof, in the Private Bill Office on the day previous to the same being proposed to be made.

That notice, in writing, of the day proposed for the third reading of every railway bill be given, by the agent soliciting the bill, to the clerks in the

Private Bill Office, one clear day before such third reading.

That all notices required to be given in the Private Bill Office be delivered in the said office before six of the clock in the evening; and that after any day on which the House shall have adjourned, no notice shall be given for the first day on which it shall again sit.

That the amendments (if any) which are made upon the report, and upon the third reading, be entered by one of the clerks in the Private Bill Office, upon the printed copy of the bill as amended by the committee; which clerk shall sign the said copy so amended, in order to its being deposited and preserved in the said office.

That to insure the accuracy of the engrossment of all railway bills, the clerk of the House be required to provide a sufficient number of clerks, to be called Examiners of Engrossments.

That no bill be read a third time, until a certificate is indorsed upon the paper bill, and signed by one or more of the said examiners of engrossments, declaring that the engrossment thereof has been examined, and agrees with the bill, as amended by the committee, and on the report.

That this House will not take into consideration the amendments made by the House of Lords to any bill sent up to them from this House, unless notice be given thereof in the Private Bill Office, not later than the day previous to the same being proposed to be taken into consideration.

That the clerks in the Private Bill Office do prepare, daily, lists of all railway bills, and petitions for railway bills upon which any committee is appointed to sit: specifying the hour of meeting, and the room where the committee shall sit; and that the same be hung up in the lobby of the House.

That every plan, and book of reference thereto, which shall be certified by the Speaker of the House of Commons, in pursuance of any act of parliament, shall previously be ascertained, and verified in such manner as shall be deemed most advisable by the Speaker, to be exactly conformable in all respects to the plan and book of reference which shall have been signed by the chairman of the committee upon the bill.

STANDING ORDERS OF THE HOUSE OF LORDS

Relative to Railway-Bills.

RAILWAY-BILLS ARE INCLUDED IN THE SECOND AND THIRD CLASSES OF PRIVATE BILLS.

The second class includes bills for making, maintaining, varying, extending, or enlarging any railway; and bills for altering or amending any act passed for the said purposes.

The third class includes bills to alter or amend any railway-act passed, and to continue or amend any former act, when no further work than such as was authorised by any former act is proposed to be made.

At the commencement of every session of parliament, a *standing order committee* shall be appointed, consisting of forty lords, besides the chairman of the committees of the House of Lords, who shall be always chairman of such standing-order committee.

That three of the Lords so appointed, including the chairman, shall be a *quorum*.

That previous to the second reading of any private bill relating to such railways as are included in the second class, and previously to the sitting of the committee on any opposed bill included in either of the two classes above mentioned, except bills for such railways as aforesaid, *such bill shall be referred to the standing-order committee, before which the compliance with such of the standing orders as are hereafter required to be proved before the standing-order committee shall be proved.*

That any *parties shall be at liberty* to appear, and *to be heard* by themselves, their agents, and witnesses, upon any petition which may be referred to the standing-order committee complaining of a non-compliance with the standing orders, *provided the matter complained of be specifically stated* in such petition, and that such petition be presented on or before the second day after the introduction of the bill into this House.

That such committee shall report *whether the standing orders have been complied with*, and if it shall appear to the committee that they have not been complied with, they shall state the facts upon which their decision is founded, and any special circumstances connected with the case, and also their opinion as to the propriety of dispensing with any of the standing orders in such case.

That *three clear days' notice* be given of the *meeting* of such committee.

That *no committee* on any private bill relating to such railways as are included in the second class, or of any other bill included in the third class above mentioned which shall be opposed, *shall have power to examine into the compliance with the standing orders*, the compliance with which is required to be proved before the standing-order committee.

That *no opposed railway bill* included in either of the two classes of bills hereinbefore mentioned *be referred to an open committee.*

That every such railway bill which shall be opposed be referred to a *select committee of five*, who shall choose their own chairman.

That *every one of such committee of five* do attend the proceedings of the committee *during the whole continuance* thereof.

That *no lord who is not one of the five* do take any part of the proceedings in the committee.

That the *lords* be *exempted* from serving on the committee on any railway bill wherein they shall have any interest.

That lords be excused from serving for any *special reasons*, to be approved of in each case by the House.

That the chairman of the committees, and four other lords to be named by the House, be appointed a committee to select and propose to the House the names of the five lords to form a *select committee for the consideration of each such opposed railway bill.*

That the select committee of five be not named to the House on the same day on which the opposed railway bill is read a second time.

That *the committee* to whom any such opposed railway bill is committed *shall meet not later than eleven o'clock every morning, and sit till four*, and shall not adjourn at an earlier hour without specially reporting the cause of such adjournment to the House at its next meeting, nor adjourn over any days except Saturday and Sunday, Christmas-day and Good-Friday, without leave of the House.

That *if any member* of such committee *is prevented from continuing his attendance, the committee shall adjourn, and report the cause* of such member absenting himself *to the House* at its next meeting, and shall not resume its sittings without leave of the House.

That the lord appointed to take the chair in all committees be at liberty, in any case on which he shall think fit, to report to the House his opinion, that *any unopposed bill* on which he shall sit as chairman *should be proceeded with as an opposed bill*.

STANDING ORDERS, THE COMPLIANCE WITH WHICH MUST BE PROVED BEFORE THE STANDING-ORDER COMMITTEE IN ALL BILLS FOR RAILWAYS INCLUDED IN THE SECOND CLASS, AND IN ANY OTHER RAILWAY BILL INCLUDED IN THE THIRD CLASS WHICH MAY BE OPPOSED.

That *notices shall be given* in all cases where application is intended to be made for a bill included in either of the two classes above mentioned.

That such *notices shall be published* in three successive weeks *in the months of October and November*, or either of them; and in the case of such railway bills as are included in the second class, in lieu of those months, twice in the month of February, and twice in the month of March, immediately preceding the session of parliament in which application for the bill shall be made, in the London, Edinburgh, or Dublin Gazette, as the case may be, and in some one and the same newspaper of the county in which the city, town, or lands to which such bill relates shall be situate; or if there is no newspaper published therein, then in the newspaper of some county adjoining or near thereto.

That if it be the intention of the parties applying for a bill *to levy any tolls, rates, or duties*, or to alter any existing tolls, rates, or duties, the *notices shall specify such intention*.

That *on or before the 31st day of December* immediately preceding the application for a bill *by which any lands or houses are intended to be taken*, or an extension of the time granted by any former act for

that purpose is sought for, *application in writing* (and in cases of bills included in the second class, in the form marked No. 1, appended hereto,) be made *to the owners, or reputed owners, lessees, or reputed lessees, and occupiers*, either by delivering the same personally, or by leaving the same at their usual place of abode, or, in their absence from the United Kingdom, with their agents respectively; and that *separate lists* be made *of such owners, lessees, and occupiers*, distinguishing which of them have assented, dissented, or are neuter in respect thereto.

That *no bill to empower any company already constituted by act of parliament to execute any work other than that for which it was originally established shall be allowed to proceed*, unless the committee on standing orders, when such bill shall be referred to that committee, or unless the committee on the bill, when the compliance with the standing orders is to be proved before such committee, shall have specially reported,—

That a draft of the proposed bill was submitted to a meeting of the proprietors of such company at a meeting held specially for that purpose.

That such meeting was called by advertisement inserted for four consecutive weeks in the newspapers of the county or counties wherein such new works were proposed to be executed, or if there are no newspapers published in such county or counties, then in that of the nearest county wherein a newspaper is published.

That such meeting was held on a period not earlier than seven days of the last insertion of such advertisement.

That at such meeting the draft of the proposed bill was submitted to the proprietors then present, and was approved of by at least three-fifths of such proprietors.

FURTHER ORDERS WITH REGARD TO RAILWAY BILLS OF THE SECOND CLASS, THE COMPLIANCE WITH WHICH IS TO BE PROVED AS HEREINBEFORE MENTIONED.

That all notices shall contain the names of the parishes, townships, and extra-parochial places from, in, through, or into which the work is intended to be made, maintained, varied, extended, or enlarged, and shall state the time and place of deposit of the plans, sections, or books of reference respectively with the clerks of the peace, parish-clerks, schoolmasters, town-clerks, and postmasters, as the case may be.

That all *notices* with respect to railway bills of

the second class *shall also be given at the general quarter sessions* of the peace which shall have been holden for every and each county, riding, or division, in or through which the work shall be made, maintained, varied, extended, or enlarged, *at Michaelmas or Epiphany preceding the session of parliament in which such application is intended to be made*, by affixing such notice on the door of the session-house of each and every such county, riding, or division, where such general quarter sessions shall be holden; save and *except as to any bill* for such purposes *in Scotland*; in which case, instead of affixing such notices on the door of the session-house, *such notices shall be written or printed on paper, and affixed to the church door* of the parish or parishes in or through which such work is intended to be made, maintained, varied, extended, or enlarged, *for two Sundays* in each of the months of *October and November* immediately preceding the introduction into Parliament of the bill for which such application is intended to be made.

That a plan, and also a duplicate of such plan, on a scale of not less than *four inches to a mile*, exhibiting thereon the height of the several embankments, and the depth of the several cuttings respectively, on a scale specified thereon, with a section and duplicate thereof as hereinafter described, be deposited for public inspection at the office of the clerk of the peace for every county, riding, or division, in England or Ireland, or in the office of the principal sheriff-clerk of every county in Scotland, in or through which the work is proposed to be made, maintained, varied, extended, or enlarged, on or before the first day of March immediately preceding the session of parliament in which application for the bill shall be made; which plans shall describe the line or situation of the whole of the work, and the lands in or through which it is to be made, maintained, varied, extended, or enlarged, or through which every communication to or from the work shall be made, together with a book of reference, containing the names of the owners or reputed owners, lessees or reputed lessees, and occupiers of such lands respectively.

That where it is the intention of the parties to apply for powers to make any *lateral deviation* from the line of the proposed work, *all lands included within the limits of such deviation shall be marked upon the plan*; and that in all cases *an additional plan of any building, yard, court-yard, or land* within the curtilage of any building, or of any ground culti-

vated as a garden, either on the original line or included within the limits of the said deviation, shall be laid down upon a scale of not less than a *quarter of an inch* to every *one hundred feet*.

That the section shall be drawn to the same horizontal scale as the plan, and to a vertical scale of not less than *one inch to every 100 feet*, and shall shew the surface of the ground marked on the plan, and a datum horizontal line, which shall be the same throughout the whole length of the work, or any branch thereof respectively, and shall be referred to some fixed point (stated in writing on the section), near either of the termini.

That the clerks of the peace or sheriff-clerks, or their respective deputies, do make a memorial in writing upon the plans, sections, and books of reference so deposited with them, denoting the time at which the same were lodged in their respective offices, and do at all seasonable hours of the day permit any person to view and examine one of the same, and to make copies or extracts therefrom; and that one of the two plans and sections so deposited be sealed up and retained in the possession of the clerk of the peace or sheriff-clerk until called for by order of one of the two Houses of Parliament.

That on or before the 1st day of April a copy of so much of the said plans and sections as relates to each parish in or through which the work is intended to be made, maintained, varied, extended, or enlarged, together with a book of reference thereto, shall be deposited with the parish-clerk of each such parish in England, the schoolmaster of each such parish in Scotland (or in royal burghs with the town-clerk), and the postmaster of the post-town in or nearest to such parish in Ireland.

That on or before the 1st day of April a copy of the said plans, sections, and books of reference shall be deposited in the office of the clerk of the parliaments.

That where any alteration shall have been made, or shall be desired by the parties to be made, after the introduction of the bill into parliament, in any railway, the bill for which shall be included in the second class, and the plans and sections for which shall have been deposited, and the notices for which shall have been given as before mentioned, a plan and section of such alteration, on the same scale and containing the same particulars as the original plan and section, together with a book of reference thereto, shall be deposited with the clerk of the peace of

every county, riding, or division, in England or Ireland, and in the office of the sheriff-clerk of every county in Scotland, in which such alteration is proposed to be made; and *a copy of such plan and section, so far as relates to each parish, together with a book of reference thereto, shall be deposited with the parish-clerks of each such parish in England, the schoolmaster of each such parish in Scotland, or in royal burghs with the town-clerk, and the postmaster of the post-town in or nearest to each such parish in Ireland*, in which such alteration is intended to be made, one month previously to the introduction of the bill for making such work into this House; and the intention to make such alteration shall be published in manner before directed in the London, Edinburgh, or Dublin Gazette, as the case may be, and some one and the same newspaper of the county in which such alteration shall be situate, or if there be no such paper printed therein, then in the newspaper of some county adjoining thereto, for three successive weeks previously to the introduction of the bill into this House; and personal application, with a notice in writing in the form hereinbefore mentioned and appended (p. lvi.), shall be made to the owners or reputed owners, lessees or reputed lessees, or, in their absence from the United Kingdom, to their agents respectively, and to the occupiers of lands through which any such alteration is intended to be made; and the consent of such owners or reputed owners, lessees or reputed lessees, and occupiers, to the making of such alteration, shall be proved to the satisfaction of the committee before whom the compliance with the standing orders shall be proved.

That previous to any bill for making a railway, the bill for which shall be included in the second class, being brought to this House from the Commons, in which any alteration has been made in its progress through Parliament, a map or plan and section of such work, shewing any variation, extension, or enlargement which is intended to be made in consequence of such alteration, *shall be deposited in the office of the clerk of the parliaments*; and that such map or plan and section shall be on the same scale and contain the same particulars as the original map or plan and section of the said work.

That *previous to the second reading* in this House of any bill included in the second class, the map or plan of the work as intended to be made by the said bill *shall be engraved or printed upon the scale of an inch at least to a mile*, and annexed to the printed

copies of the bill, and shall be laid upon the table of this House.

That *copies of so much of the standing orders of this House on railway bills, as relates to the deposit of plans, sections, books of reference, and other books and writings, or extracts or copies of or from the same*, with the clerks of the peace of counties in England or Ireland, sheriff-clerks in Scotland, parish-clerks in England, schoolmasters in Scotland, town-clerks of royal burghs in Scotland, postmasters in Ireland, and other persons, *be delivered to every such clerk of the peace, sheriff-clerk, parish-clerk, schoolmaster, postmaster, and other person*, at the same time with the plan or other writing, or extract or copy of or from such plan or other writing, deposited with him.

That before any application is made for a bill whereby any *part of a work* authorised by any former act *is intended to be relinquished*, notice in writing of such bill be given to the owners or reputed owners and occupiers of the lands in which the part of the said work intended to be thereby relinquished is situate.

That an estimate of the expense be made, and signed by the person making the same, and that a subscription be entered into under a contract, made as hereinafter described, to *three-fourths the amount of the estimate*.

Provided, that in cases where the work is to be made by means of funds, or out of money to be raised upon the credit of present surplus revenue, under the control of directors, of any existing railway, a declaration to that effect, setting forth the nature and amount of such funds and revenue, and given under the common seal of the company, or under the hand of some authorised officer of such directors, may be substituted in lieu of such subscription-contract.

That *all subscription contracts shall contain the christian and surnames, description and place of abode of every subscriber, his signature to the amount of his subscription, with the amount which he has paid up, and the name of the party witnessing such signature, and the date of the same respectively*; and that it be proved to the satisfaction of the committee before whom the compliance with the standing orders shall be proved, that a sum equal to one-twentieth part of the amount subscribed has been deposited with the Court of Exchequer in England, if the work is intended to be done in England, or with the Court of Exchequer in England or the Court of Exchequer in Scotland, if such work is intended to

be done in Scotland, or with the Court of Chancery in Ireland, if such work is intended to be done in Ireland, and that not less than three-fourths in number of the subscribers have paid up their shares of such deposit.

That no subscription contract shall be valid unless it be entered into subsequent to the close of the session of parliament previous to that in which application is made for the bill to which it relates, and unless the parties subscribing to it bind themselves, their heirs, executors, and administrators, for the payment of the money so subscribed.

That *previous to the second reading of the bill, copies of the subscription contract, with the names of the subscribers arranged in alphabetical order, and the amount of the deposit respectively paid by each such subscriber, or where a declaration and estimate are substituted in lieu of a subscription contract, copies of such declaration and estimate, be printed at the expense of the promoters of the bill, and be delivered at the office of the clerk of the parliament for the use of this House.*

STANDING ORDERS FOR RAILWAY BILLS OF THE SECOND CLASS, TO BE PROVED BEFORE THE COMMITTEE ON STANDING ORDERS.

That the line of the railway marked upon the section shall correspond with the upper surface of the rails.

That a vertical measure from the datum line to the line of the railway shall be marked in feet and inches at each change of the gradient or inclination, and that the proportion or rate of inclination between each such change shall also be marked.

That the height of the railway over or under the surface of every turnpike-road, public carriage-road, navigable river, canal, or railway, or junction with a railway, shall be marked in figures at every crossing thereof, and if there shall be no such crossing in every half mile, then the height over or under the surface of the ground shall be marked once in that space: and if any alteration in the present level or rate of inclination of any turnpike-road, carriage-road, or railway be intended, then the same shall be stated on the said section.

That when tunnelling or a substitute for open cutting, or arching as a substitute for solid embankment, is intended, the same shall be marked both on the plan and section.

That parties desiring to deviate from the line of any railway, of which the plans, sections, and books

of reference shall have been deposited, and for which the notices shall have been given as before directed, shall be permitted so to do, provided *no one deviation shall exceed one mile in length*, and provided a plan and section, as before described, of such deviation, together with a book of reference thereof, shall be deposited with the clerk of the peace of every county, riding, or division in England or Ireland, or in the office of the principal sheriff-clerk of every county in Scotland, in which such deviation is proposed to be made, and a plan and section so far as relates to each parish, together with a book of reference thereto, with the parish-clerks of each such parish in England, the schoolmaster of each such parish in Scotland (or in royal burghs with the town-clerk), and the postmaster of the post-town in or nearest to each such parish in Ireland, in which such deviation is proposed to be made, on or before the 30th day of November immediately preceding the application to Parliament; and that the intention to make each deviation shall be published, in manner before directed, in three successive weeks in the months of October and November, or either of them; and that on or before the 31st day of December immediately preceding such application to Parliament, application in writing be made to the owners or reputed owners, lessees or reputed lessees, and occupiers of the lands through which such deviation is proposed to be made, either by delivering the same personally, or by leaving the same at their usual place of abode, or, in their absence from the United Kingdom, with their agents respectively: and that separate lists be made of such owners, lessees, and occupiers, distinguishing which of them have assented, dissented, or are neutral in respect thereto.

That parties desiring to renew any application to Parliament in respect of any railway of which the plans, sections, and books of reference shall have been deposited, and for which the notices shall have been given as before directed, shall be permitted so to do in the session next ensuing that in which such application to Parliament was made, provided a plan and section, as before described, of such railway, together with a book of reference thereto, shall be deposited with the clerk of the peace of every county, riding, or division in England or Ireland, or in the office of the principal sheriff-clerk of every county in Scotland, in or through which such railway is proposed to be made: and a plan and section as before described, so far as relates to each parish, together with a book of reference thereto, with the

parish-clerks of each such parish in England, the schoolmaster of each such parish in Scotland (or in royal burghs with the town-clerk), and the postmaster of the post-town in or nearest to each such parish in Ireland through which such railway is proposed to be made, on or before the 30th day of November immediately preceding such renewed application to Parliament, and that the intention to make such application shall be published in manner before directed, in the months of October and November, or either of them; and that on or before the 31st day of December immediately preceding such renewed application to Parliament, application in writing be made to the owners or reputed owners, lessees or reputed lessees, and occupiers of the lands through which any such railway is proposed to be made, either by delivering the same personally, or by leaving the same at their usual place of abode, or, in their absence from the United Kingdom, with their agents respectively; and that separate lists be made of such owners, lessees, and occupiers, distinguishing which of them have assented, dissented, or are neuter in respect thereto.

STANDING ORDERS WITH REGARD TO RAILWAY BILLS OF THE SECOND CLASS, TO BE PROVED BEFORE THE COMMITTEE ON THE BILL.

That where the level of any road shall be altered in making any railway, the *ascent* of any *turnpike-road* shall not be more than *one foot in thirty feet*, and of any other public carriage-road not more than *one foot in twenty feet*; and that a *good and sufficient fence of four feet high* at the least shall be made on each side of every bridge which shall be erected.

That in case the work intended to be carried into effect under the authority of the bill shall not have been completed, so as to answer the object of such bill, within a time to be limited, all the powers and authorities thereby given shall thenceforth cease and determine, save only as to so much of such work as shall have been completed within such time, with such provisions and qualifications as the nature of the case shall require.

STANDING ORDERS WITH REGARD TO THE PROCEEDINGS OF COMMITTEES ON RAILWAY BILLS, TO BE PROVED BEFORE THE COMMITTEE ON THE BILL, WHO ARE DIRECTED TO REPORT SPECIALLY ON THE FOLLOWING MATTERS OF INQUIRY.

As to the *proposed capital* of the company formed for the execution of the project, and the *amount of any loans* which they may be empowered to raise by

the bill, the *amount of shares* subscribed for, and the *deposits paid thereon*; the *names and places of residence of the directors or provisional committee*, with the *amount of shares taken by each*; the *number of shareholders* who may be considered as *having a local interest in the line*, and the amount of capital subscribed for by them; and the number of other parties, and the capital taken by them; a statement of the number of *shareholders subscribing for 2000l.* and upwards, with their names and residences, and the amount for which they have subscribed.

The *sufficiency or insufficiency* for agricultural, commercial, manufacturing, or other purposes, of the *present means of conveyance*, and of communication between the proposed termini, stating the present amount of traffic by land or water, the average charges made for passengers and goods, and time occupied.

The *number of passengers*, and the *weight and description of the goods expected* upon the proposed railway.

The amount of *income expected* to arise from the conveyance of passengers and goods, and in what proportion; stating also generally the description of goods from which the largest revenue is anticipated.

Whether the proposed railway be a complete and integral line between the termini specified, or a part of a more extended plan now in contemplation, and likely to be hereafter submitted to Parliament, and to what extent the calculations of remuneration depend on such contemplated extension of the line.

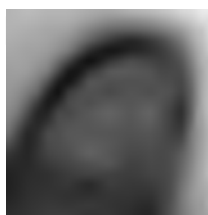
Whether any, and what, competing lines of railway there are existing, and whether any, and what, are in progress or contemplation, and to state, so far as circumstances will permit, in what respects the proposed line is superior or inferior to the other lines, if there be any; provided always, that *no line of railway shall be deemed a competing line* in contemplation, *unless the plans and sections for the same*, such as are required by the standing orders respecting railway bills, *shall have been deposited with the clerk of the peace and in the office of the clerk of the Parliaments, on or before the first day of March then last past.*

To state what *planes* on the railway are proposed to be worked, either by *assistant engines*, stationary or locomotive, with the respective lengths and inclinations of such planes.

To advert to any *peculiar engineering difficulties* in the proposed line, and to report the manner in which it is intended they should be overcome.

Specific replies are to be given in answer to each of the questions contained in the first of the standing

And in it further stated. That it shall not be
admitted for the said company to purchase in the above



tion of the said railway hereinbefore authorised to be made, *unless the said company shall have*, previously to the commencement of such work, *deposited* with the clerk of the peace of the several counties in England or Ireland, and in the office of the principal sheriff-clerk in every county in Scotland, in or through which the said railway hereby authorised to be made is intended to pass, *a plan and section of all such alterations from the original plan and section as shall have been approved of by Parliament*, on the same scale, and containing the same particulars, as the original plan and section of the railway; and also with the clerks of the several parishes in England, the schoolmasters of the several parishes in Scotland (or in the royal burghs with the town-clerk), and the postmasters of the post-towns in or nearest to such parishes in Ireland in or through which such alterations shall have been authorised to be made, copies or extracts of or from such plans and sections as shall relate to such parishes respectively; and all persons interested shall have liberty to inspect and make extracts from, or copies of the said plans and sections, or extracts or copies thereof, paying to the officer having the custody of such plan and section, or of such extract or copy, the sum of one shilling for every such inspection, and after the rate of sixpence for every one hundred words copied therefrom.

And be it further enacted, That in making the said railway, it shall *not* be lawful for the said company *to deviate from the levels of the said railway*, as referred to the common datum line described on the section so approved of by Parliament, and as marked on the same, to any extent *exceeding in any place five feet, or in passing through towns two feet*, without the consent of the owners, lessees, and occupiers of the land in, through, or over which such deviation is intended to be made; or *in case any street or public carriage-road shall be affected by such deviation*, then the *same shall not be made without the consent of the trustees or commissioners*, or, if there be no such trustees or commissioners, without *the consent of two or more justices of the peace* in petty sessions assembled for that purpose, and acting for the district in which such street or public carriage-road may be situate, or without the consent of the commissioners for any public sewers, or the proprietors of any canal or navigation affected by such deviation; and that *no increase in the inclinations or gradients of the said railway, as denoted by the said section, shall be made in any place to an extent exceeding the rate of three feet per mile*; and

where in any place it is intended to carry the railway on an arch or arches, as marked on the said plan or section, the *same shall be made accordingly*; and *where a tunnel is marked on the said plan or section as intended to be made at any place, the same shall be made accordingly*, unless the owners, lessees, and occupiers of the land in or through which such tunnel is intended to be made shall consent that the same shall not be so made: provided, nevertheless, that it shall be lawful for the said company, with such consent as aforesaid, and not otherwise, to make a tunnel or an arch or arches as aforesaid not marked on the said plan or section, so that no such tunnel shall be of greater length than two hundred yards, and that no two tunnels be at a less distance from each other than one hundred yards measured on the line of the railway: provided always, that notice of every petty sessions to be holden for the purpose of obtaining such consent as aforesaid shall, fourteen days previous to the holding of such petty sessions, be given in some newspaper circulating in the county, and also to be affixed upon the church-door of the parish in which such deviation or alteration is intended to be made, or, if there be no church, on some other place to which notices are usually affixed; provided also, that, for the purpose of consenting to any such deviation from the said sections, and to any tunnelling or arching as aforesaid, the word 'owners' shall be deemed and taken to mean such persons as are herein capacitated to agree for the sale of, and to convey land for the making of the said railway; and the consent of such persons, with or without the consent of any other persons interested as owners in the said lands, shall be deemed and taken to be sufficient for such purposes.

And be it further enacted, That it shall *not* be *lawful to diminish the radius of any curve*, as described on the plan deposited with the clerk of the peace, or principal sheriff-clerk, *unless such radius exceed one mile*, nor to diminish it in any such case so that it shall become less than one mile, nor to diminish any greater radius by more than a quarter of a mile unless where it exceeds two miles, or by more than half a mile unless where it exceeds three miles on the said plan.

That *all private bills relating to railways, which shall have been opposed, and in which any amendments shall have been made in the committee, shall be reprinted as amended previously to the third reading*, unless the chairman of the committee shall certify that the reprinting of such bill is unnecessary.

FORM OF APPLICATION TO OWNERS, LESSEES, AND OCCUPIERS,

As referred to above in the orders of both Houses of Parliament.

No.

SIR,

WE beg to inform you, that application is intended to be made to Parliament, in the ensuing session for "an Act" [*here insert the title of the act*], and that the property mentioned in the annexed schedule, or some part thereof, in which we understand you are interested as therein stated, will be required for the purposes of the said undertaking, according to the line thereof as at present laid out, or may be required to be taken under the usual powers of deviation to the extent of yards on either side of the said line which will be applied for in the said act, and will be passed through in the manner mentioned in such schedule.

We also beg to inform you, that a plan and section of the said undertaking, with a book of reference thereto, has been, or will be deposited with the several clerks of the peace (*or sheriff-clerks*) of the counties of [*specify the counties in which the property is situate*], on or before the 30th of November or the 1st of March [*as the case may be*], and that copies of so much of the said plan and section as relates to the parish (*or royal burgh*) in which your property is situate, with a book of reference thereto,

has been or will be deposited for public inspection with the clerk of the said parish, schoolmaster of the parish, town-clerk of the royal burgh, or the postmaster of the post-town in or nearest such parish [*as the case may be*], on or before the 31st day of December instant, or on or before the 1st of April instant [*as the case may be*], on which plans your property is designated by the numbers set forth in the annexed schedule.

As we are required to report to Parliament whether you assent to or dissent from the proposed undertaking, or whether you are neuter in respect thereto, you will oblige us by writing your answer of assent, dissent, or neutrality, in the form left herewith, and returning the same to us with your signature, on or before the day of next; and if there should be any error or misdirection in the annexed schedule, we shall feel obliged by your informing us thereof, at your earliest convenience, that we may correct the same without delay. We are,

SIR,

Your most obedient servants,

To

SCHEDULE referred to in the foregoing Notice.

—	Parish.	Number on Plans.	Description.	Owner.	Lessee.	Occupier.	Description of the Section of the Line deposited, and of the greatest height of Embankment and depth of Cutting.
Property in the Line as at present laid down on the Plans, &c.							
—	Parish.	Number on Plans.	Description.	Owner.	Lessee.	Occupier.	
Property within the Limits of the Deviation-line intended to be applied for.							

1st Vict., cap. 83.—*An Act to compel Clerks of the Peace for Counties and other Persons to take the Custody of such Documents as shall be directed to be deposited with them under the Standing Orders of either House of Parliament.*

Whereas the Houses of Parliament are in the habit of requiring that, previous to the introduction of any bill into Parliament for making certain bridges, turnpike-roads, cuts, canals, reservoirs, aqueducts, waterworks, navigations, tunnels, archways, railways, piers, ports, harbours, ferries, docks, and other works, to be made under the authority of Parliament, certain maps, or plans and sections, and books and writings, or extracts or copies of or from certain maps, plans or sections, books and writings, shall be deposited in the office of the clerk of the peace for every county, riding, or division in England or Ireland, or in the office of the sheriff-clerk of every county in Scotland, in which such work is proposed to be made, and also with the parish-clerk in every parish in England, the schoolmaster of every parish of Scotland, or in royal burghs with the town-clerk, and the postmaster of the post-town in or nearest to every parish in Ireland, in which such work is intended to be made, and with other persons: and whereas it is expedient that such maps, plans, sections, books, writings, and copies or extracts of and from the same should be received by the said clerks of the peace, sheriff-clerks, parish-clerks, schoolmasters, town-clerks, postmasters, and other persons, and should remain in their custody for the purposes hereinafter mentioned; be it therefore enacted by the Queen's most excellent majesty, by and with the advice and consent of the Lords spiritual and temporal, and Commons, in this present Parliament assembled, and by the authority of the same, that whenever either of the Houses of Parliament shall by its standing orders, already made or hereafter to be made, require that any such maps, plans, sections, books, or writings, or extracts or copies of the same, or any of them, shall be deposited as aforesaid, such maps, plans, sections, books, writings, copies and extracts shall be received by and shall remain with the clerks of the peace, sheriff-clerks, parish-clerks, schoolmasters, town-clerks, postmasters, and other persons with whom the same shall be directed by such standing orders to be deposited, and they are hereby respectively directed to receive and to retain the custody of all such documents and

writings, so directed to be deposited with them respectively, in the manner and for the purposes and under the rules and regulations concerning the same respectively directed by such standing orders, and shall make such memorials and endorsements on, and give such acknowledgments and receipts in respect of the same respectively as shall be thereby directed.

II. And be it further enacted, That all persons interested shall have liberty to, and the said clerks of the peace, sheriff-clerks, parish-clerks, schoolmasters, town-clerks, and postmasters, and every of them, are and is hereby required, at all reasonable hours of the day, to permit all persons interested to inspect during a reasonable time, and make extracts from or copies of the said maps, plans, sections, books, writings, extracts, and copies of or from the same, so deposited with them respectively, on payment by each person to the clerk of the peace, sheriff-clerk, clerk of the parish, schoolmaster, town-clerk, or postmaster, having the custody of any such map, plan, section, book, writing, extract, or copy, one shilling for every such inspection, and the further sum of one shilling for every hour during which such inspection shall continue after the first hour, and after the rate of sixpence for every one hundred words copied therefrom.

III. And be it further enacted, That in case any clerk of the peace, sheriff-clerk, parish-clerk, schoolmaster, town-clerk, postmaster, or other person, shall in any matter or thing refuse or neglect to comply with any of the provisions hereinbefore contained, every clerk of the peace, sheriff-clerk, parish-clerk, schoolmaster, town-clerk, postmaster, or other person, shall for every such offence forfeit and pay any sum not exceeding the sum of five pounds, and every such penalty shall, upon proof of the offence before any justice of the peace for the county within which such offence shall be committed, or by the confession of the party offending, or by the oath of any credible witness, be levied and recovered, together with the costs of the proceedings for the recovery thereof, by distress and sale of the goods and effects of the party offending, by warrant under the hand of such justice, which warrant such justice is hereby empowered to grant, and shall be paid to the person or persons making such complaint; and it shall be lawful for any such justice of the peace to whom any complaint shall be made of any offence committed against this act, to summon the party complained of before him, and on such summons to hear and determine the matter of such complaint in a summary

way, and on proof of the offence to certify the offender, and to adjudge him to pay the penalty or forfeiture incurred, and to proceed to recover the same, although no information in writing or in print shall have been exhibited or taken by or before such justice; and all such proceedings by summons without information shall be as good, valid, and effectual, to all intents and purposes, as if an information in writing had been exhibited.

1st and 2d Vict. cap. 117.—*An Act to provide for the custody of certain monies paid in pursuance of the Standing Orders of either House of Parliament, by subscribers to works or undertakings to be effected under the authority of Parliament.*

Whereas it is expedient to provide for the custody of any sums of money paid in pursuance of any standing order of the Lords spiritual and temporal in Parliament assembled, or of the Commons in Parliament assembled, by subscribers to works or undertakings to be made under the authority of an act of Parliament: be it therefore enacted by the Queen's most excellent majesty, by and with the advice and consent of the Lords spiritual and temporal, and Commons, in this present Parliament assembled, and by the authority of the same, that in all cases in which any sum of money is required by any standing order of either House of Parliament, either now or hereafter to be in force, to be paid by the subscribers to any work or undertaking which is to be executed under the authority of an act of Parliament, if the director or person, or directors or persons, having the management of the affairs of any such proposed work or undertaking, or any five of them, shall apply to the chairman of the committee of the House of Lords with respect to any such money required by any standing order of the Lords spiritual and temporal in Parliament assembled, or to the Speaker of the House of Commons, with respect to any such money required by any standing order of the Commons in Parliament assembled, the said chairman or the said Speaker may, by warrant or order under his hand, direct that such sum of money shall be paid in manner hereinafter mentioned; that is to say, into the Bank of England, in the name and with the privity of the accountant-general of the Court of Exchequer in England, if the work or undertaking in respect of which the sum of money is required to be paid is intended to be executed in that part of the United Kingdom called England; or into the Bank of Eng-

land in the name and with the privity of the said accountant-general, or into any of the banks in Scotland established by act of Parliament or royal charter, in the name and with the privity of the Queen's remembrancer of the Court of Exchequer in Scotland, at the option of the person or persons making such application as aforesaid, in case such work or undertaking is intended to be executed in that part of the United Kingdom called Scotland: or into the Bank of Ireland, in the name and with the privity of the accountant-general of the Court of Chancery in Ireland, in case such work or undertaking is intended to be made or executed in that part of the United Kingdom called Ireland: and every such application as aforesaid to the said chairman or Speaker shall be made in writing, and be signed by the director or directors, or person or persons, having the management of the said work or undertaking, or by any five of them; and therein shall be stated the name or description of such work or undertaking, and name and place of abode, or the names and places of abode of such director or directors, person or persons, and the sum of money required to be paid, and the bank and name into and in which the same is to be paid; and such particulars shall also be set forth in every such warrant or order; and such warrant or order shall be a sufficient authority for the accountant-general of the said Court of Exchequer in England, the Queen's remembrancer of the Court of Exchequer in Scotland, and the accountant-general of the Court of Chancery in Ireland respectively, to permit the sum of money directed to be paid by such warrant or order to be placed to an account opened or to be opened in his name in the bank mentioned in such warrant or order.

II. And be it enacted, that it shall be lawful for the person or persons named in such warrant or order, or the survivors or survivor of them, or any five of them, to pay the sum of money mentioned in such warrant or order into the bank mentioned in such warrant or order, in the name and with the privity of the officer or person in whose name such sum shall be directed to be paid by such warrant or order, to be placed to his account there *ex parte* the work or undertaking mentioned in such warrant or order; and every such sum so paid in, or the securities in or upon which the same may be invested as hereinafter mentioned, shall there remain until the same or such securities as aforesaid shall be paid out of such bank in pursuance of the provisions of

this act: provided always, that every sum paid into the Bank of England in the name and with the privity of the accountant-general of the Court of Exchequer under the provisions of this act, shall be paid in and placed to his account there, pursuant to the method prescribed by an act passed in the first year of the reign of his late majesty King George the Fourth, intituled, "An Act for the better securing money and effects paid into the Court of Exchequer at Westminster on account of the suitors of the said court, and for the appointment of an accountant-general and two masters of the said court, and for other purposes, and pursuant to the general orders of the said court, and without fee or reward;" and every sum paid into the Bank of Ireland in the name and with the privity of the accountant-general of the Court of Chancery in Ireland, under the provisions of this act, shall be paid in and placed to his account, pursuant to the method prescribed by an act made and passed in the Parliament of Ireland in the twenty-third and twenty-fourth years of the reign of his late majesty King George the Third, intituled, "An Act for the better securing the monies and effects of the suitors of the Court of Chancery and Exchequer, by depositing the same in the national bank, and to prevent the forging and counterfeiting any draft, order, or other voucher, for the payment or delivery of such money and effects, and for other purposes," and pursuant to the general orders of the said court, and without fee or reward.

III. And be it enacted, that if the person or persons named in such warrant or order, or the survivor or survivors of them, or any five of them, desire to have invested any sum so paid into the Bank of England or the Bank of Ireland, the court in the name of whose accountant-general the same may have been paid, on a petition presented to such court in a summary way by him or them, may order that such sum shall, until the same be paid out of court in pursuance to this act, be laid out in the three per centum consolidated or three per centum reduced bank annuities, or any government security or securities.

IV. And be it enacted, that on the termination

of the session of Parliament in which the petition or bill for the purpose of making or sanctioning any such work or undertaking shall have been introduced into Parliament, or if such petition or bill shall be rejected or finally withdrawn by some proceeding in either House of Parliament, or shall not be allowed to proceed, or if an act be passed authorising the making of such work or undertaking; and if in any or either of the foregoing cases the person or persons named in such warrant or order, or the survivor or survivors of them, or the majority of such persons, apply by petition to the court in the name of whose accountant-general the sum of money mentioned in such warrant or order shall have been paid, or to the Court of Exchequer in Scotland in case such sum of money shall have been paid in the name of the said Queen's remembrancer, the court in the name of whose accountant-general or Queen's remembrancer such sum of money shall have been paid, shall, by order, direct the sum of money paid in pursuance of such warrant or order, or the stocks, funds, or securities, in or upon which the same are invested, and the interest or dividends thereof, to be transferred and paid to the party or parties so applying, or to any other person or persons whom they may appoint in that behalf; but no such order shall be made in the case of any such petition or bill being rejected, or not being allowed to proceed, or withdrawn, unless it be proved by the certificate of the chairman of committees, if the said petition or bill was rejected or not allowed to proceed, or withdrawn in its passage through the House of Lords; or of the said speaker, if the said petition or bill was rejected or not allowed to proceed, or withdrawn during its passage through the House of Commons, that the petition or bill has been either so rejected, or not allowed to proceed, or so withdrawn by some proceeding in one or other House of Parliament; which certificate the said chairman or speaker shall grant on the application in writing of the person or persons, or the majority of the persons named in such warrant or order, or the survivor or survivors of them; and every such certificate shall be conclusive proof of such rejection, or not proceeding, or withdrawal.

ANNO TERTIO ET QUARTO VICTORIÆ REGINÆ.

Cap. 97. *An Act for regulating Railways.*—Aug. 10, 1840.

No Railway to be opened without notice to the Board of Trade.

WHEREAS it is expedient for the safety of the public to provide for the due supervision of railways; be it therefore enacted by the Queen's most excellent majesty, by and with the advice and consent of the Lords spiritual and temporal, and Commons, in this present Parliament assembled, and by the authority of the same, That after two months from the passing of this act, no railway or portion of any railway shall be opened for the public conveyance of passengers or goods, until one calendar month after notice in writing of the intention of opening the same shall have been given, by the company to whom such railway shall belong, to the Lords of the Committee of her Majesty's Privy Council appointed for trade and foreign plantations.

Penalty for opening railways without notice.

II. And be it enacted, That if any railway or portion of any railway shall be opened without due notice as aforesaid, the company to whom such railway shall belong shall forfeit to her Majesty the sum of twenty pounds for every day during which the same shall continue open, until the expiration of one calendar month after the company shall have given the like notice as is hereinbefore required before the opening of the railway; and any such penalty may be recovered in any of her Majesty's courts of record.

Returns to be made by railway companies.

III. And be it enacted, That the Lords of the said committee may order and direct every railway company to make up and deliver to them returns, according to a form to be provided by the Lords of the said committee, of the aggregate traffic in passengers, according to the several classes, and of the aggregate traffic in cattle and goods respectively on the said railway, as well as of all accidents which shall have occurred thereon attended with personal injury, and also a table of all tolls, rates, and charges from time to time levied on each class passengers, and on cattle and goods conveyed on the said railway; and if the returns herein specified shall not be delivered within thirty days after the same shall have been required, every such company shall forfeit to her Majesty the sum of twenty pounds for every day during which the said company shall wilfully neglect to deliver the same; and every such penalty may be recovered in any of her Majesty's courts of record: provided always, that such returns shall be required, in like manner, and at the same time, from all the said companies, unless the Lords of the said committee shall specially exempt any of the said companies, and shall enter the grounds of such exemption in the minutes of their proceedings.

Penalty for making false returns.

IV. And be it enacted, That every officer of any company who shall wilfully make any false return to the Lords of the said committee shall be deemed guilty of a misdemeanour.

Board of Trade may appoint persons to inspect railways.

V. And be it enacted, That it shall be lawful for the Lords of the said committee, if and when they shall think fit, to authorise any proper person or persons to inspect any railway; and it shall be lawful for every person so authorised, at all reasonable times, upon producing his authority, if required, to enter upon and examine the said railway, and the stations, works, and buildings, and the engines and carriages belonging thereto: provided always, that no person shall be eligible to the appointment as inspector as aforesaid who shall within one year of his appointment have been a director, or have held any office of trust or profit under any railway company.

Penalty on persons obstructing inspector.

VI. And be it enacted, That every person wilfully obstructing any person duly authorised as aforesaid, in the execution of his duty, shall, on conviction before a justice of the peace having jurisdiction in

the place where the offence shall have been committed, forfeit and pay for every such offence any sum not exceeding ten pounds; and on default of payment of any penalty so adjudged, immediately or within such time as the said justice of the peace shall appoint, the same justice, or any other justice having jurisdiction in the place where the offender shall be or reside, may commit the offender to prison for any period not exceeding three calendar months; such commitment to be determined on payment of the amount of the penalty; and every such penalty shall be returned to the next ensuing court of quarter sessions in the usual manner.

VII. And whereas many railway companies are, or may hereafter be, empowered by act of Parliament to make by-laws, orders, rules, or regulations, and to impose penalties for the enforcement thereof upon persons other than the servants of the said companies, and it is expedient that such powers should be under proper control; be it enacted, That true copies of all such by-laws, orders, rules, and regulations, made under any such powers by every such company before the passing of this act, certified in such manner as the Lords of the said committee shall from time to time direct, shall, within two calendar months after the passing of this act, be laid before the Lords of the said committee; and that every such by-law, order, rule, or regulation, not so laid before the Lords of the said committee within the aforesaid period, shall, from and after that period, cease to have any force or effect, saving in so far as any penalty may have been then already incurred under the same.

Copies of existing by-laws to be laid before the Board of Trade;

otherwise to be void.

VIII. And be it enacted, That no such by-law, order, rule, or regulation, made under any such power, and which shall not be in force at the time of the passing of this act, and no order, rule, or regulation, annulling any such existing by-law, rule, order, or regulation, which shall be made after the passing of this act, shall have any force or effect, until two calendar months after a true copy of such by-law, order, rule, or regulation, certified as aforesaid, shall have been laid before the Lords of the said committee, unless the Lords of the said committee shall before such period signify their approbation thereof.

No future by-laws to be valid till two calendar months after they have been laid before the Board of Trade.

IX. And be it enacted, That it shall be lawful for the Lords of the said committee, at any time either before or after any by-law, order, rule, or regulation, which shall have been laid before them as aforesaid, shall have come into operation, to notify to the company who shall have made the same their disallowance thereof; and, in case the same shall be in force at the time of such disallowance, the time at which the same shall cease to be in force; and no by-law, order, rule, or regulation which shall be so disallowed shall have any force or effect whatsoever; or, if it shall be in force at the time of such disallowance, it shall cease to have any force or effect at the time limited in the notice of such disallowance, saving in so far as any penalty may have been then already incurred under the same.

Board of Trade may disallow by-laws.

X. And be it enacted, That so much of every clause, provision, and enactment, in any act of Parliament heretofore passed as may require the approval or concurrence of any justice of the peace, court of quarter sessions, or other person or persons other than members of the said companies, to give validity to any by-laws, orders, rules, or regulations made by such company, shall be repealed.

Provisions of railway acts requiring confirmation of by-laws repealed.

XI. And be it enacted, That whenever it shall appear to the Lords of the said committee that any of the provisions of the several acts of Parliament regulating any of the said companies, or the provisions of this act, have not been complied with on the part of any of the said companies, or any of their officers, and that it would be for the public advantage that the due performance of the same should be enforced, the Lords of the said committee shall certify the same to her Majesty's Attorney-General for *England* or *Ireland*, or to the Lord Advocate for *Scotland*, as the case may require; and thereupon the said Attorney-General or Lord Advocate shall, by information, or by action, bill, plaint, suit at law or in equity, or other legal proceeding, as the case may require, proceed to recover such penalties and forfeitures, or otherwise to enforce the due performance of the said provisions, by such means as any person aggrieved by such non-compliance, or otherwise authorised to sue for such penalties, might employ under the provisions of the said acts: provided always, that no such certificate as aforesaid shall be given by the Lords

Board of Trade may direct prosecutions to enforce provisions of railway acts.

Notice to be given to the company.

of the said committee, until twenty-one days after they shall have given notice of their intention to give the same to the company against or in relation to whom they shall intend to give the same.

Prosecutions to be under sanction of Board of Trade, and within one year after the offence.
Punishment of servants of railway companies guilty of misconduct.

XII. And be it enacted, That no legal proceedings shall be commenced under the authority of the Lords of the said committee against any railway company for any offence against this act, or any of the several acts of Parliament relating to railways, except upon such certificate of the Lords of the said committee as aforesaid, and within one year after such offence shall have been committed.

XIII. And be it enacted, That it shall be lawful for any officer or agent of any railway company, or for any special constable duly appointed, and all such persons as they may call to their assistance, to seize and detain any engine-driver, guard, porter, or other servant in the employ of such company who shall be found drunk while employed upon the railway, or commit any offence against any of the by-laws, rules, or regulations of such company, or shall wilfully, maliciously, or negligently do, or omit to do, any act whereby the life or limb of any person passing along or being upon the railway belonging to such company, or the works thereof respectively, shall be or might be injured or endangered, or whereby the passage of any of the engines, carriages, or trains shall be or might be obstructed or impeded; and to convey such engine-driver, guard, porter, or other servant so offending, or any person counselling, aiding, or assisting in such offence, with all convenient despatch, before some justice of the peace for the place within which such offence shall be committed, without any other warrant or authority than this act; and every such person so offending, and every person counselling, aiding, or assisting therein as aforesaid, shall, when convicted before such justice as aforesaid (who is hereby authorised and required, upon complaint to him made, upon oath, without information in writing, to take cognizance thereof, and to act summarily in the premises), in the discretion of such justice, be imprisoned, with or without hard labour, for any term not exceeding two calendar months, or, in the like discretion of such justice, shall for every such offence forfeit to her Majesty any sum not exceeding ten pounds, and in default of payment thereof shall be imprisoned, with or without hard labour as aforesaid, for such period, not exceeding two calendar months, as such justice shall appoint; such commitment to be determined on payment of the amount of the penalty; and every such penalty shall be returned to the next ensuing court of quarter sessions in the usual manner.

Justice of the peace empowered to send any case to be tried by the quarter sessions.

XIV. Provided always, and be it enacted, That (if upon the hearing of any such complaint he shall think fit) it shall be lawful for such justice, instead of deciding upon the matter of complaint summarily, to commit the person or persons charged with such offence for trial for the same at the quarter sessions for the county or place wherein such offence shall have been committed, and to order that any such person so committed shall be imprisoned and detained in any of her Majesty's gaols or houses of correction in the said county or place in the meantime, or to take bail for his appearance, with or without sureties, in his discretion; and every such person so offending, and convicted before such court of quarter sessions as aforesaid (which said court is hereby required to take cognizance of and hear and determine such complaint), shall be liable, in the discretion of such court, to be imprisoned, with or without hard labour, for any term not exceeding two years.

Punishment of persons obstructing railway.

XV. And be it enacted, That from and after the passing of this Act, every person who shall wilfully do or cause to be done any thing in such manner as to obstruct any engine or carriage using any railway, or to endanger the safety of persons conveyed in or upon the same, or shall aid or assist therein, shall be guilty of a misdemeanour, and, being convicted thereof, shall be liable, at the discretion of the court before which he shall have been convicted, to be imprisoned, with or without hard labour, for any term not exceeding two years.

For punishment of persons obstructing the officers of any railway

XVI. And be it enacted, That if any person shall wilfully obstruct or impede any officer or agent of any railway company in the execution of his duty upon any railway, or upon or in any of the stations or other works or premises connected therewith, or if any person shall wilfully trespass upon any railway, or any of the stations or other works or premises connected therewith, and shall refuse to quit the same upon

request to him made by any officer or agent of the said company, every such person so offending, and all others aiding or assisting therein, shall and may be seized and detained by any such officer or agent, or any person whom he may call to his assistance, until such offender or offenders can be conveniently taken before some justice of the peace for the county or place wherein such offence shall be committed; and when convicted before such justice as aforesaid (who is hereby authorised and required, upon complaint to him upon oath, to take cognizance thereof, and to act summarily in the premises,) shall, in the discretion of such justice, forfeit to her Majesty any sum not exceeding five pounds, and in default of payment thereof, shall or may be imprisoned for any term not exceeding two calendar months, such imprisonment to be determined on payment of the amount of the penalty.

company, or trespassing upon any railway.

XVII. And be it enacted, That no proceeding to be had and taken in pursuance of this Act shall be quashed or vacated for want of form, or be removed by *certiorari*, or by any other writ or process whatsoever, into any of her Majesty's courts of record at Westminster or elsewhere, any law or statute to the contrary notwithstanding.

Proceedings not to be quashed for want of form, or removed into the superior courts.

XVIII. And whereas many railway companies are bound, by the provisions of the Acts of Parliament by which they are incorporated or regulated, to make, at the expense of the owner or occupier of lands adjoining the railway, openings in the ledges or flanches thereof (except at certain places on such railway in the said Acts specified), for effecting communications between such railway and any collateral or branch railway to be laid down over such lands, and any disagreement or difference which shall arise as to the proper places for making any such openings in the ledges or flanches, is by such Acts directed to be referred to the decision of any two justices of the peace within their respective jurisdictions. And whereas it is expedient that so much of every clause, provision, and enactment, in any Act of Parliament heretofore passed, as gives to any justice or justices the power of hearing or deciding upon any such disagreement or difference as to the proper places for any such openings in the ledges or flanches of any railway, should be repealed: be it therefore enacted, That so much of every such clause, provision, and enactment as aforesaid shall be repealed.

Repeal of all provisions in railway acts that empower two justices to decide disputes respecting the proper places for openings in the ledges or flanches of railways.

XIX. And be it enacted, That in case any disagreement or difference shall arise between any such owner or occupier, or other persons, and any railway company, as to the proper places for any such openings in the ledges or flanches of any railway (except at such places as aforesaid), for the purpose of such communication, then the same shall be left to the decision of the Lords of the said committee, who are hereby empowered to hear and determine the same in such way as they shall think fit, and their determination shall be binding on all parties.

Board of Trade to determine such disputes in future.

XX. And be it enacted, That all notices, returns, and other documents, required by this Act to be given to or laid before the Lords of the said committee, shall be delivered at or sent by the post to the office of the Lords of the said committee; and all notices, appointments, requisitions, certificates, or other documents in writing, signed by one of the secretaries of the said committee, or by some officer appointed for that purpose by the Lords of the said committee, and purporting to be made by the Lords of the said committee, shall, for the purposes of this Act, be deemed to have been made by the Lords of the said committee; and service of the same upon any one or more of the directors of any railway company, or on the secretary or clerk of the said company, or by leaving the same with the clerk or officer at one of the stations belonging to the said company, shall be deemed good service upon the said company.

Communications to the Board to be left at their office.

Communications by the Board, how to be authenticated.

What shall be deemed good service on railway company.

XXI. And be it enacted, That wherever the word "railway" is used in this Act, it shall be construed to extend to all railways constructed under the powers of any Act of Parliament, and intended for the conveyance of passengers in or upon carriages drawn or impelled by the power of steam or by any other mechanical power; and wherever the word "company" is used in this Act, it shall be construed to extend to and include the proprietors for the time being of any such railway, whether a body corporate or indi-

Meaning of the words "railway" and "company."

viduals, and their lessees, executors, administrators, and assigns, unless the subject or context be repugnant to such construction.

Act may be
repealed this
session.

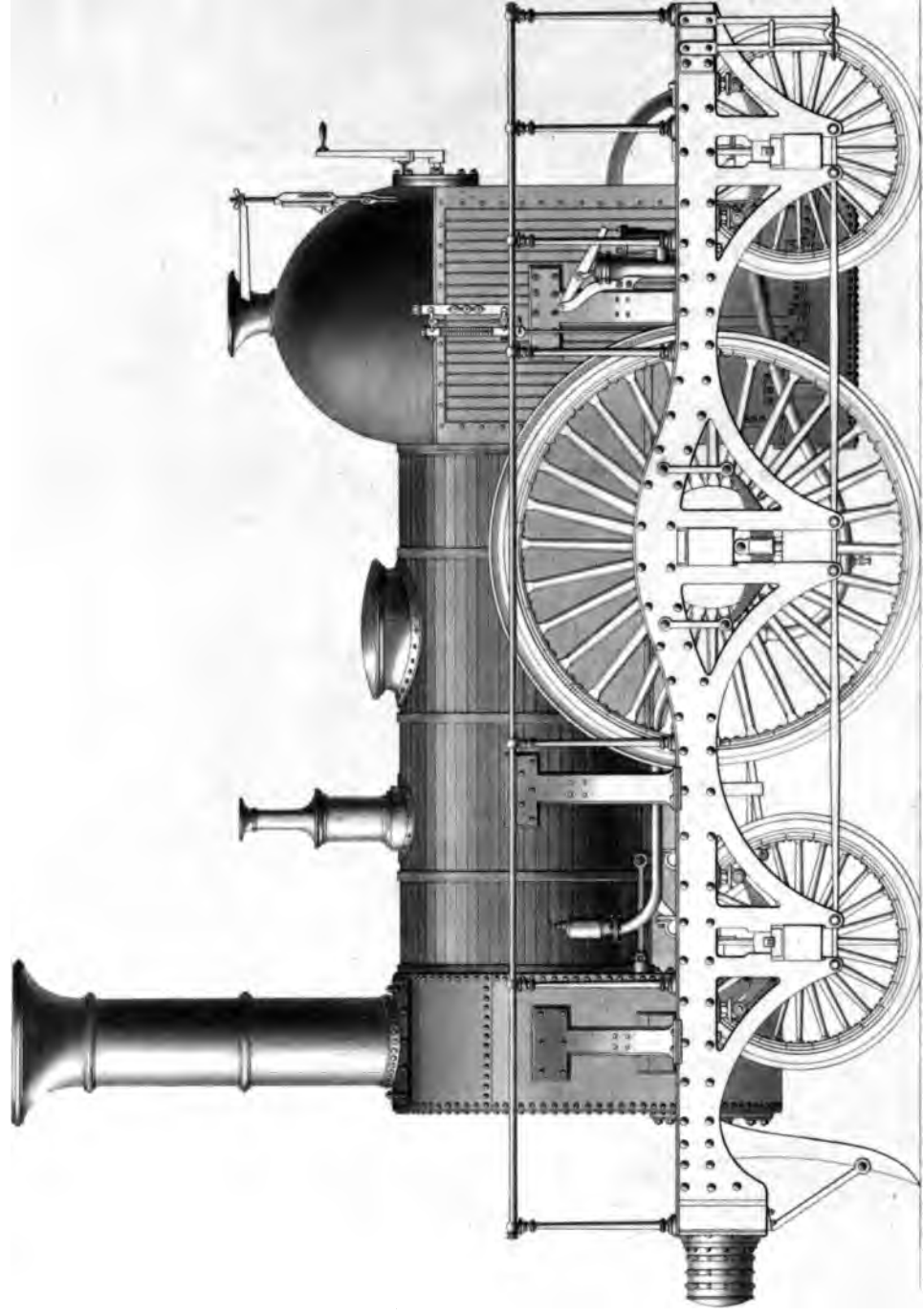
XXII. And be it enacted, That this Act may be amended or repealed by any Act to be passed in the present session of Parliament.

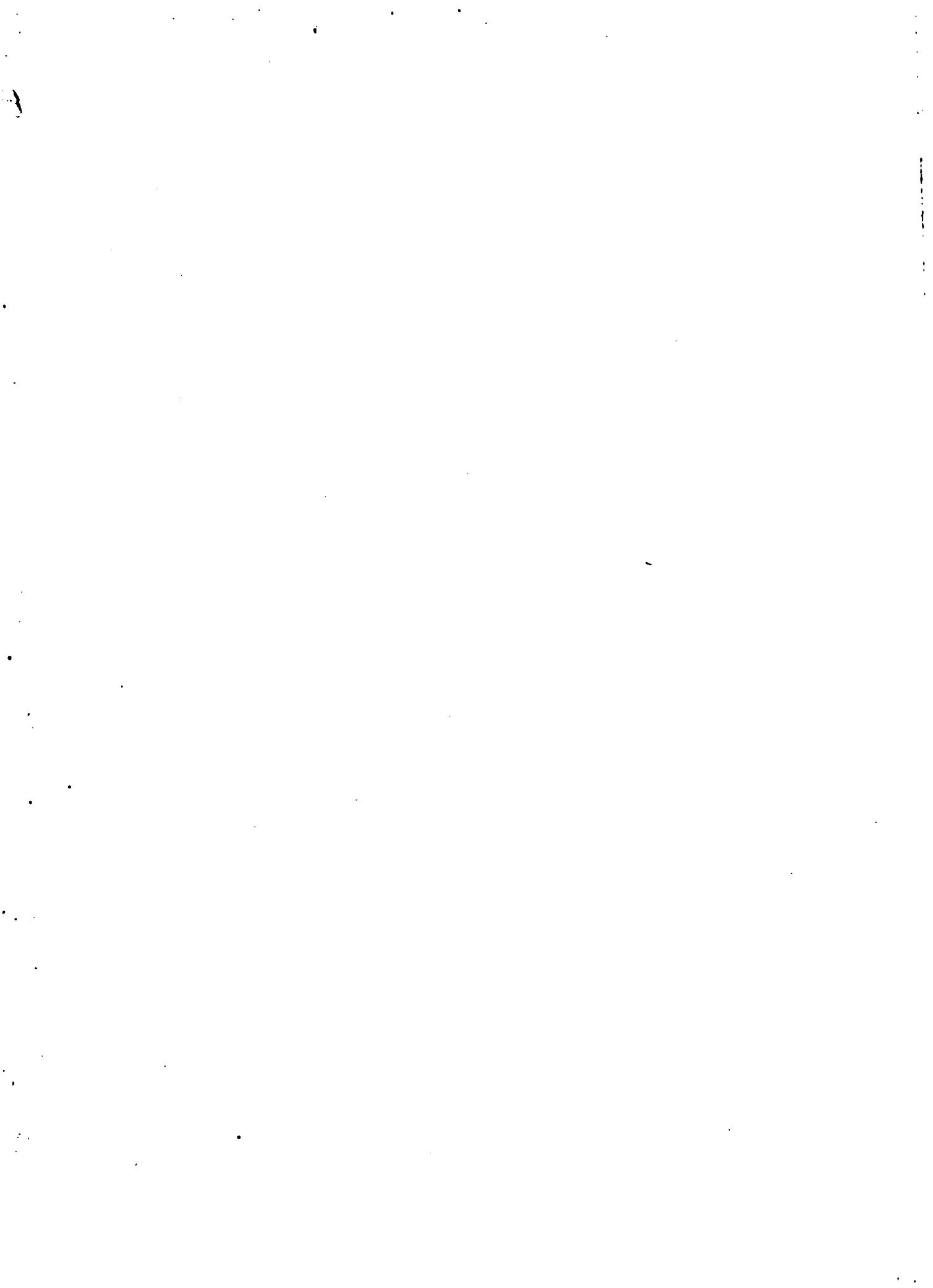
THE END.

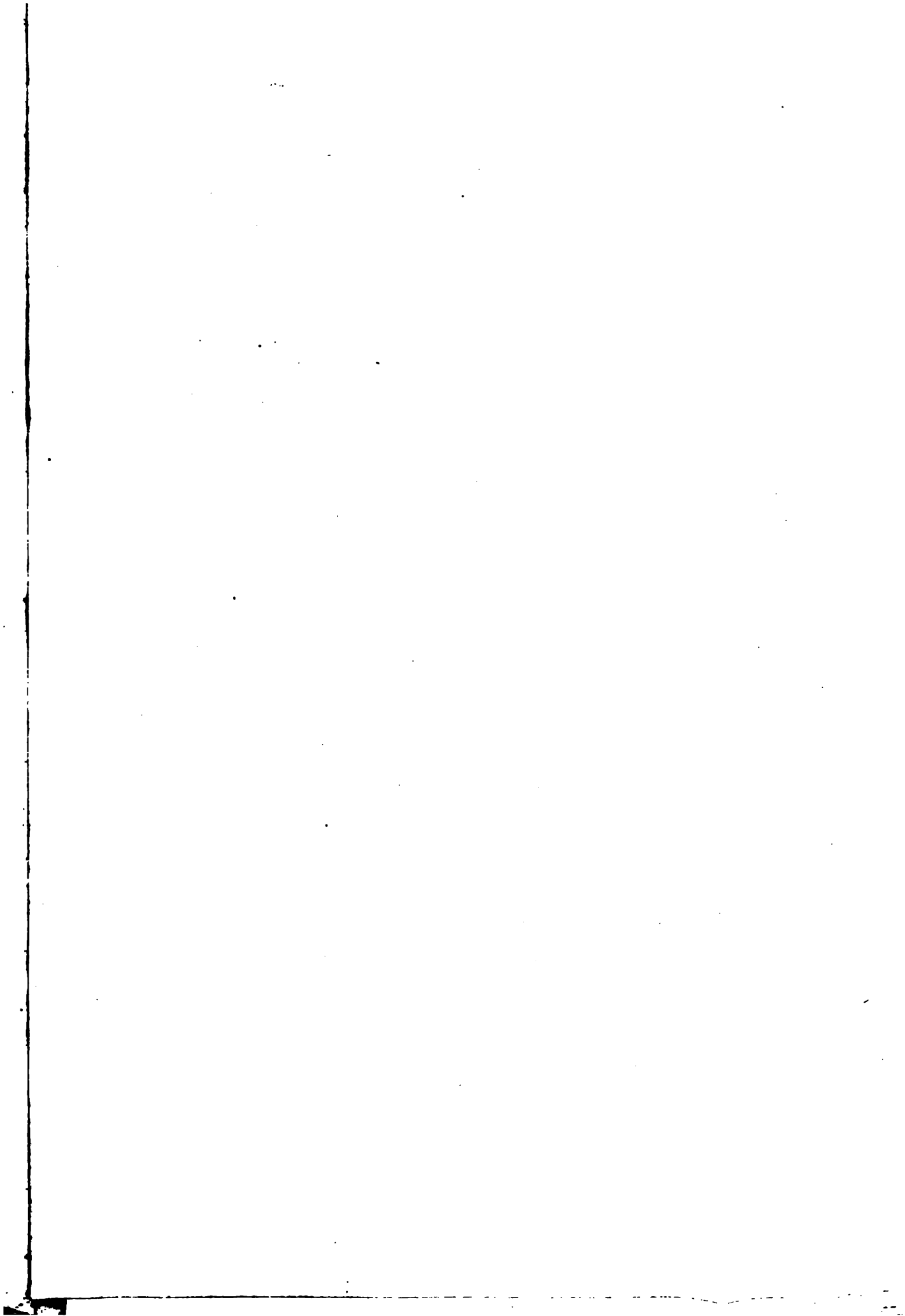
LONDON :
PRINTED BY ROBSON, LEVEY, AND FRANKLYN,
46 St. Martin's Lane.

LOCOMOTIVE ENGINE ON THE GREAT WESTERN RAILWAY

CLASS A





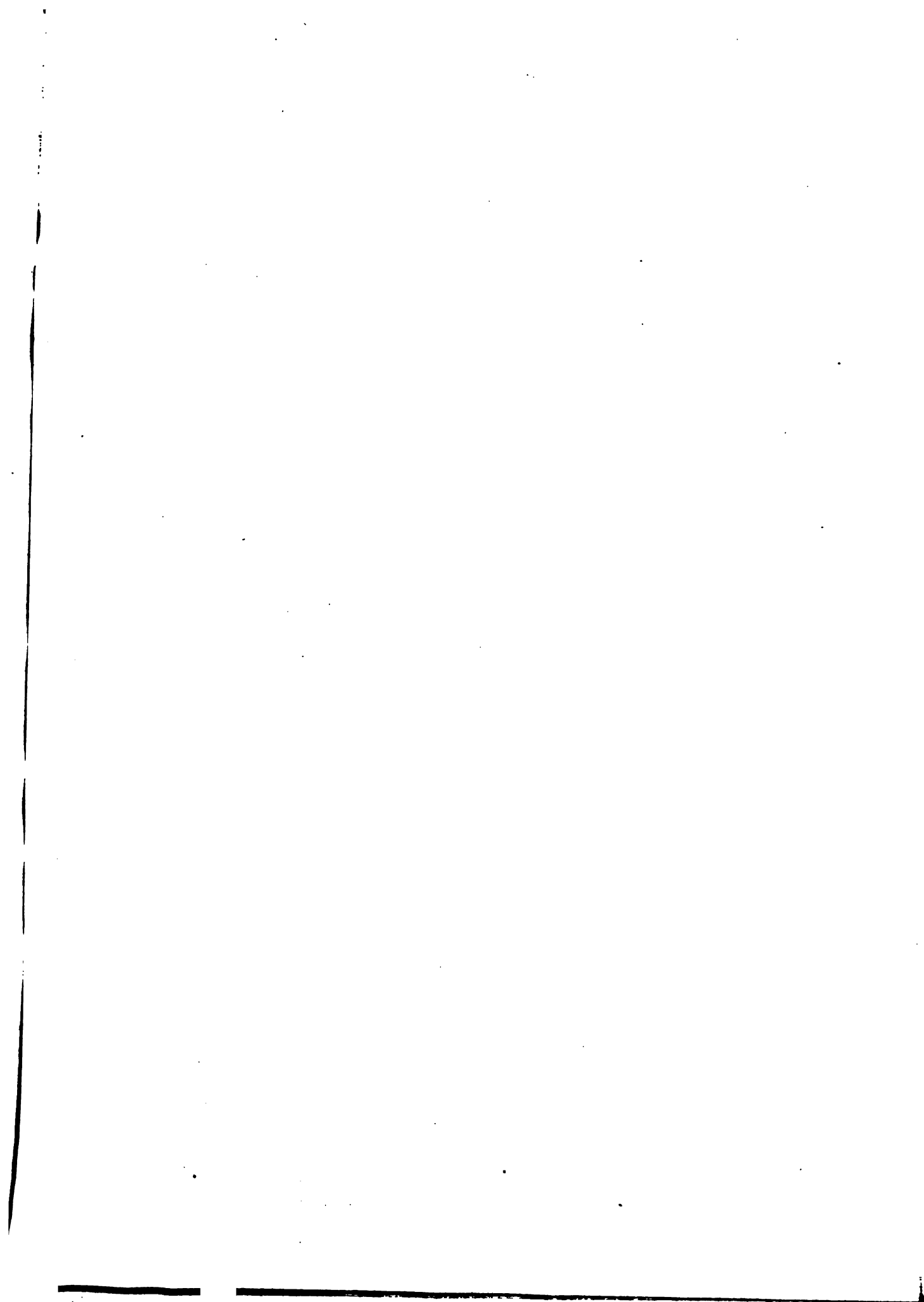


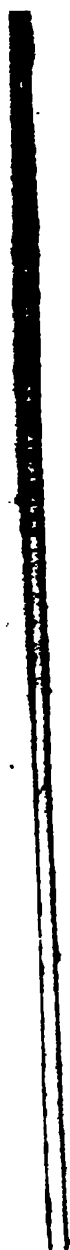
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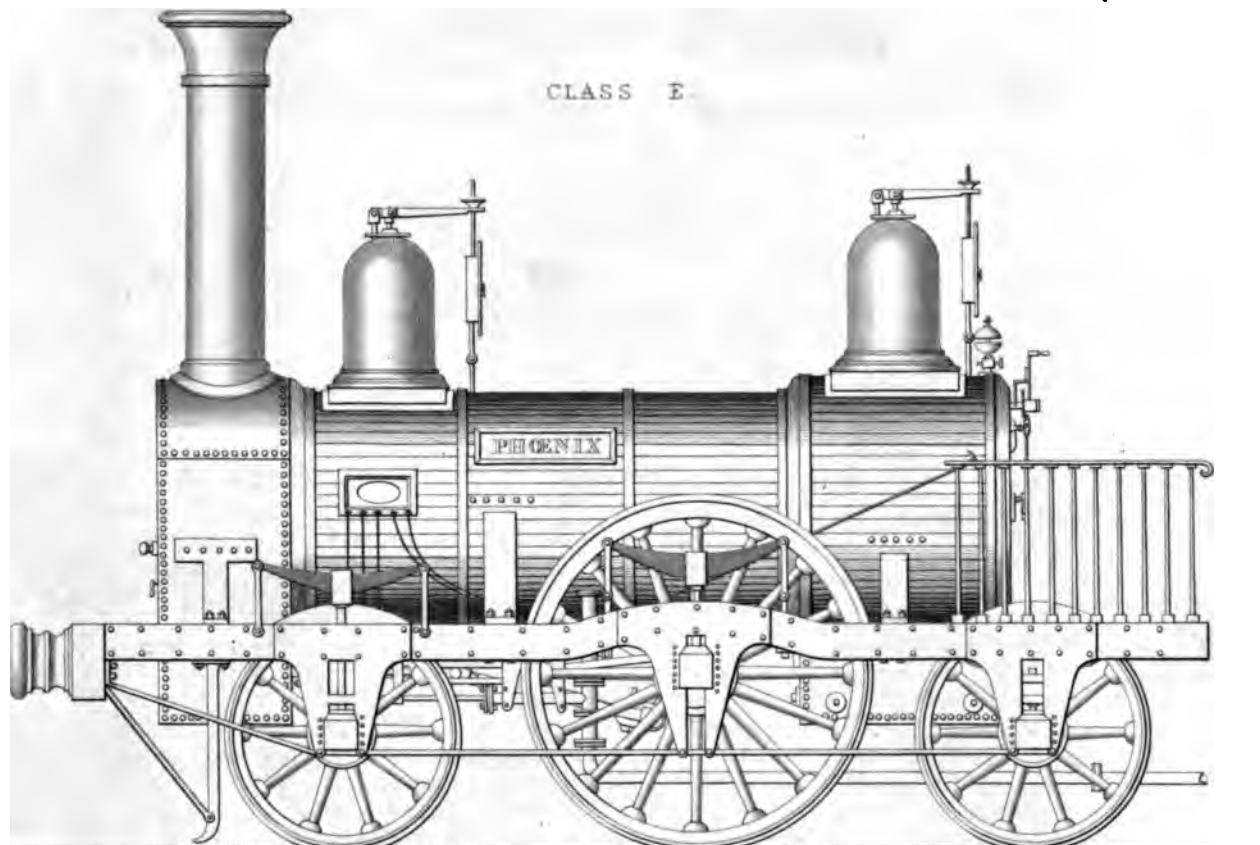
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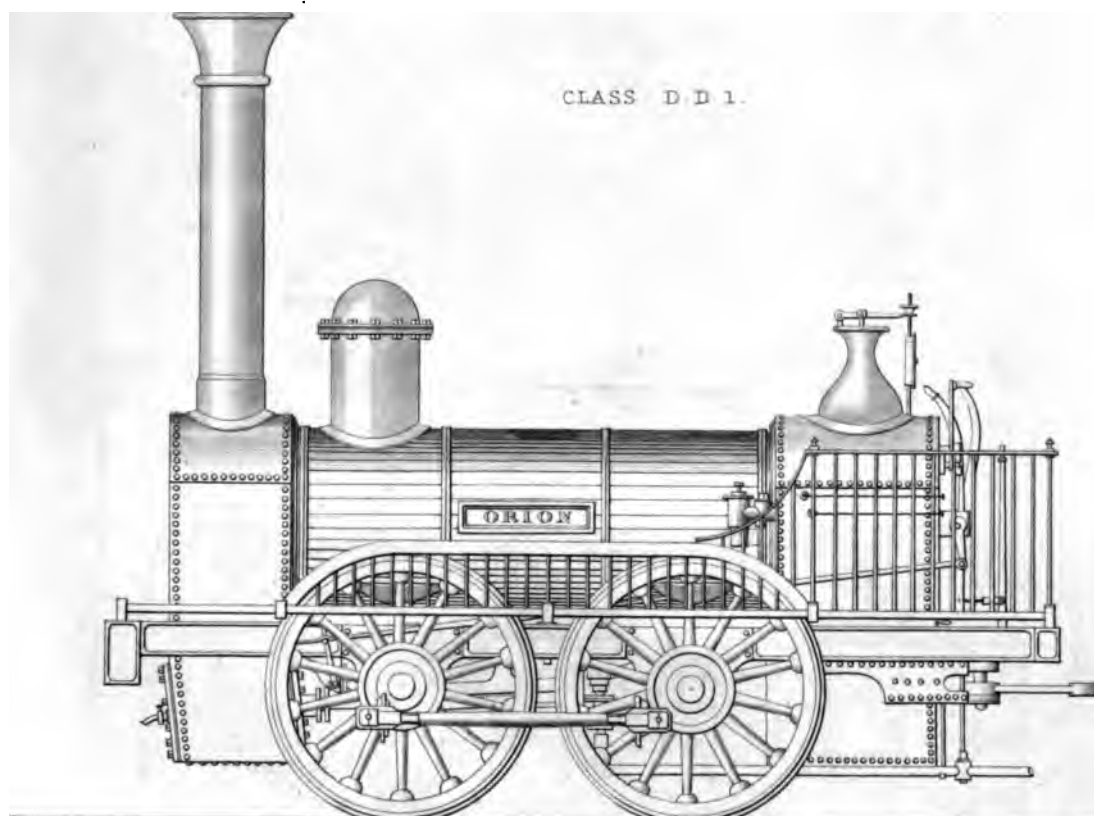
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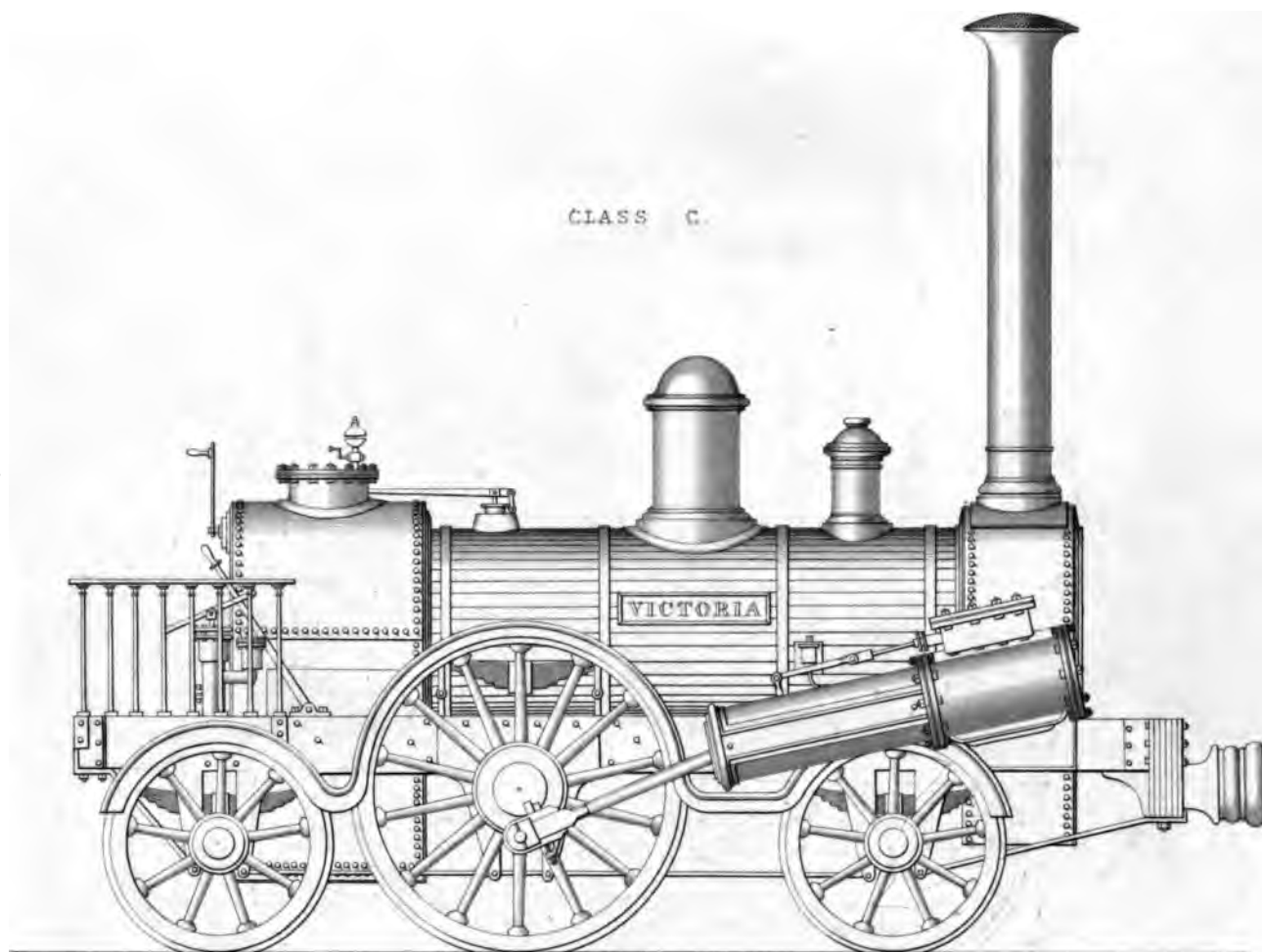




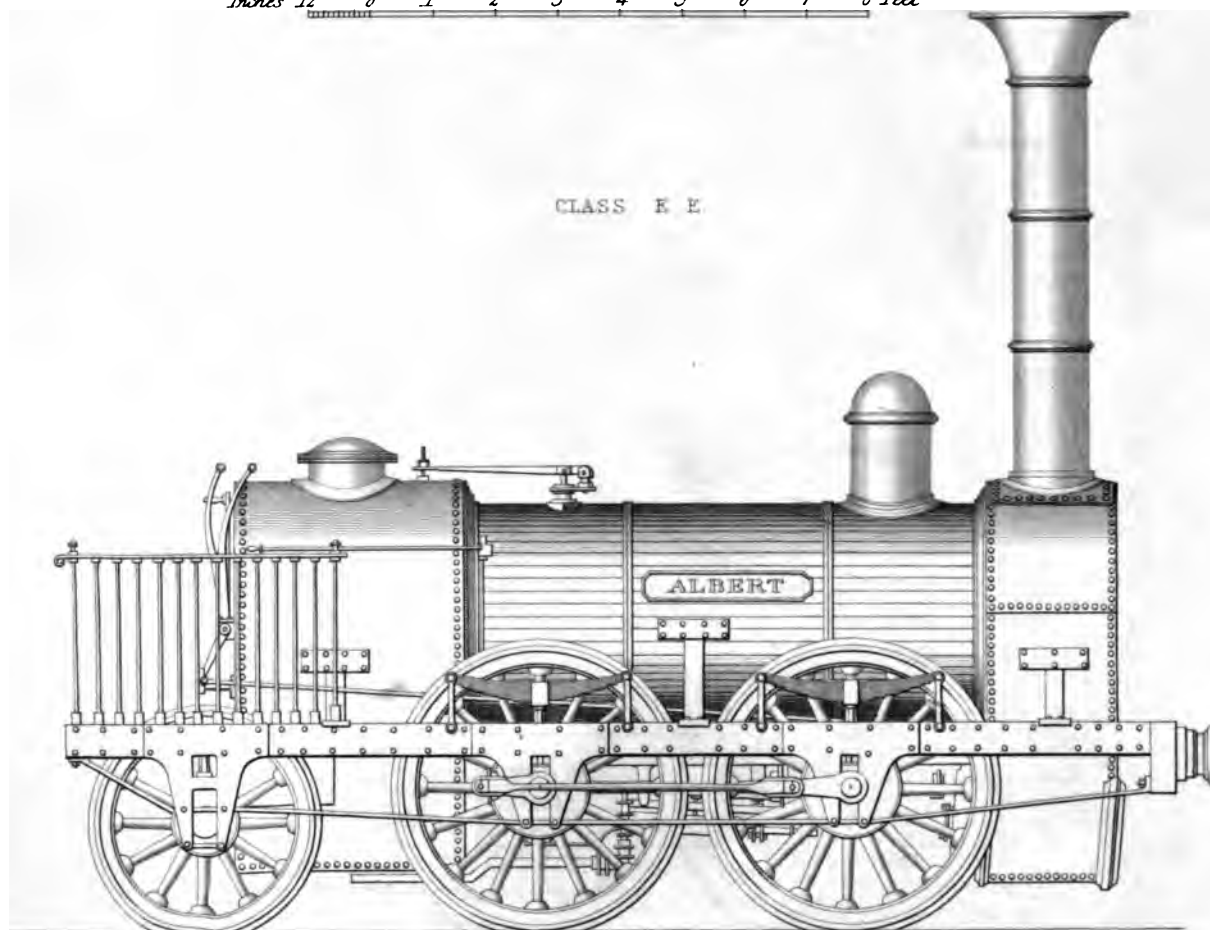


Inches 12 0 1 2 3 4 5 6 7 8 Feet



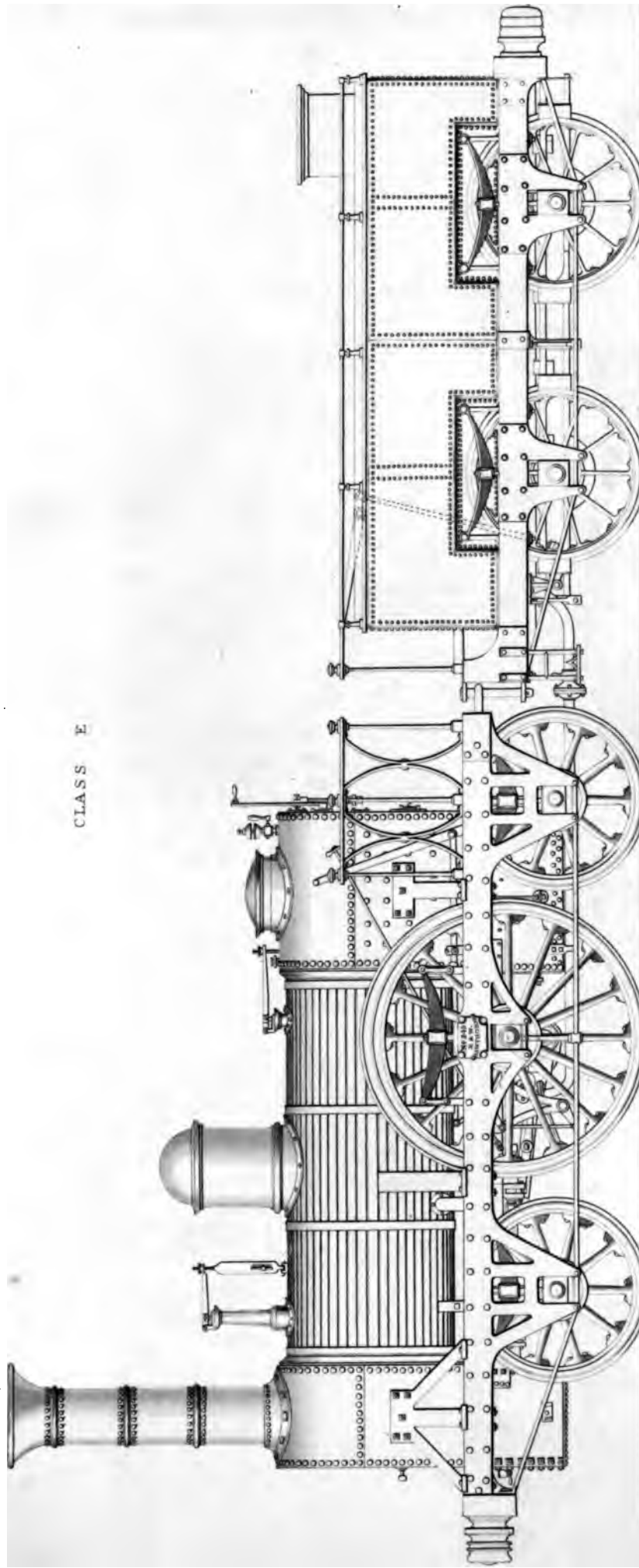


Inches 12 0 1 2 3 4 5 6 7 8 Feet



1

ENGINE & TENDER, CONSTRUCTED BY R & W. HAWTHORN. - NEWCASTLE.



CLASS E



Red Rumble del

R. Mossell sc.

London: Simpkin, Marshall & Co. Ltd.

100

100

ELEVATION OF AMERICAN LOCOMOTIVE ENGINE

AT WORK ON THE

BIRMINGHAM & GLOSTER RAILWAY.

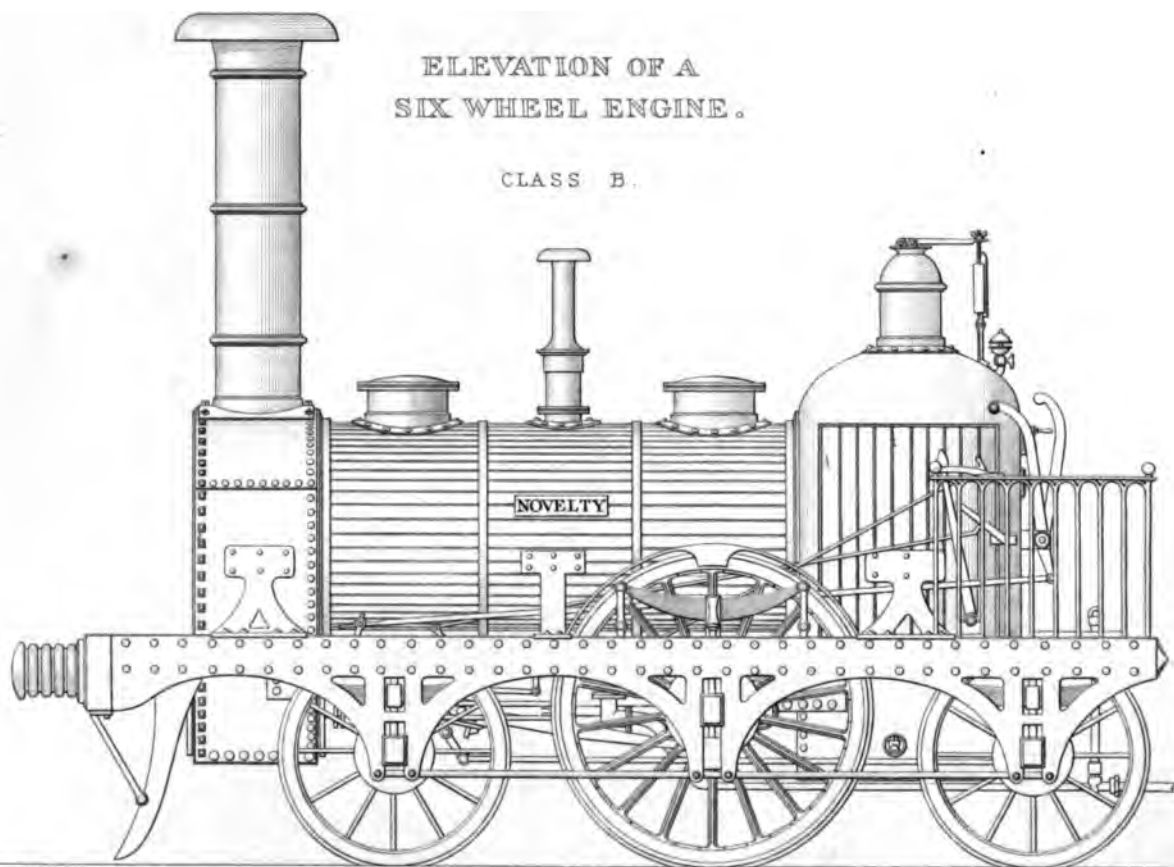
CLASS F



G.B.W. Jackson. del.

ELEVATION OF A
SIX WHEEL ENGINE.

CLASS B.



F. Rumble del.

London.

PASSENGER ENGINE
ON THE
LONDON & BIRMINGHAM RAILWAY.

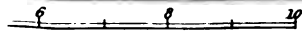
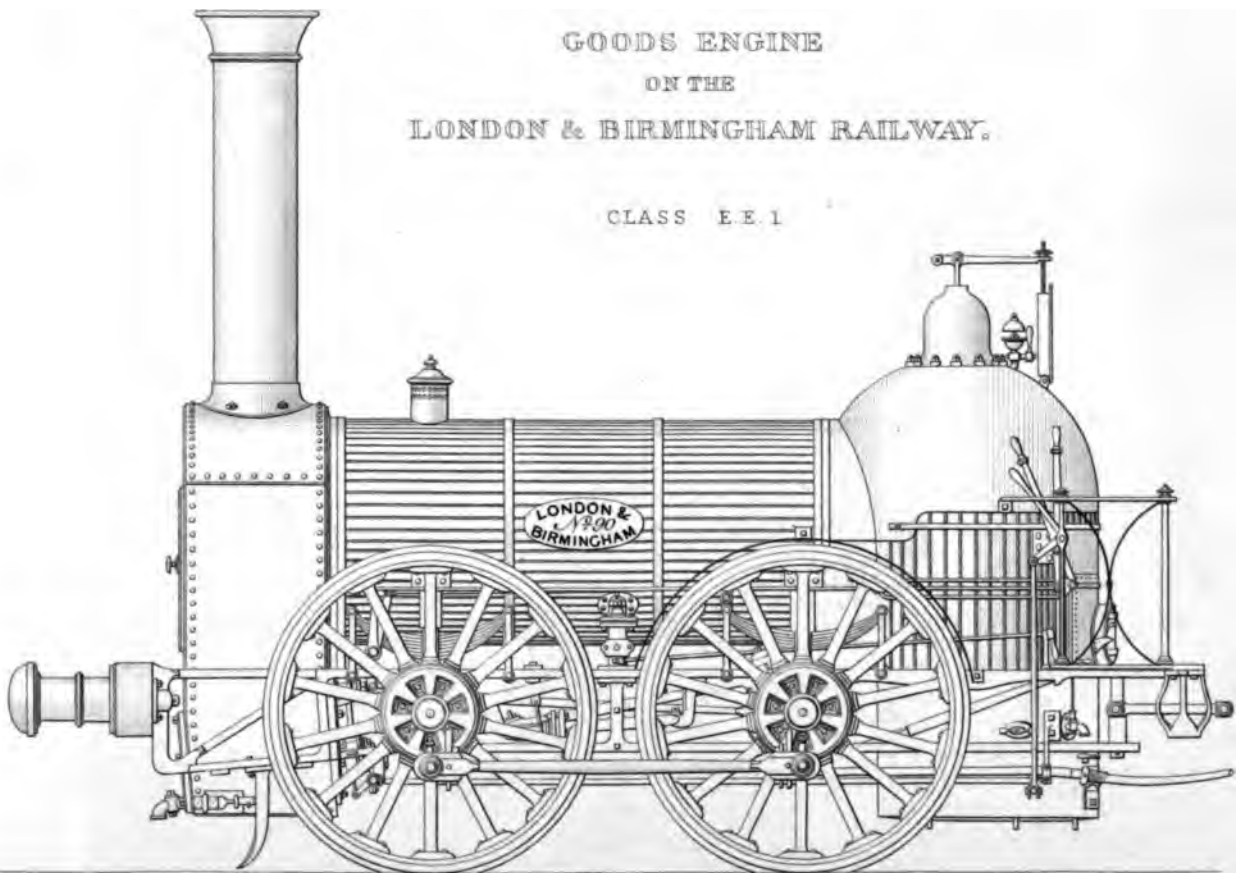
CLASS E. 1.



F Rumble del.

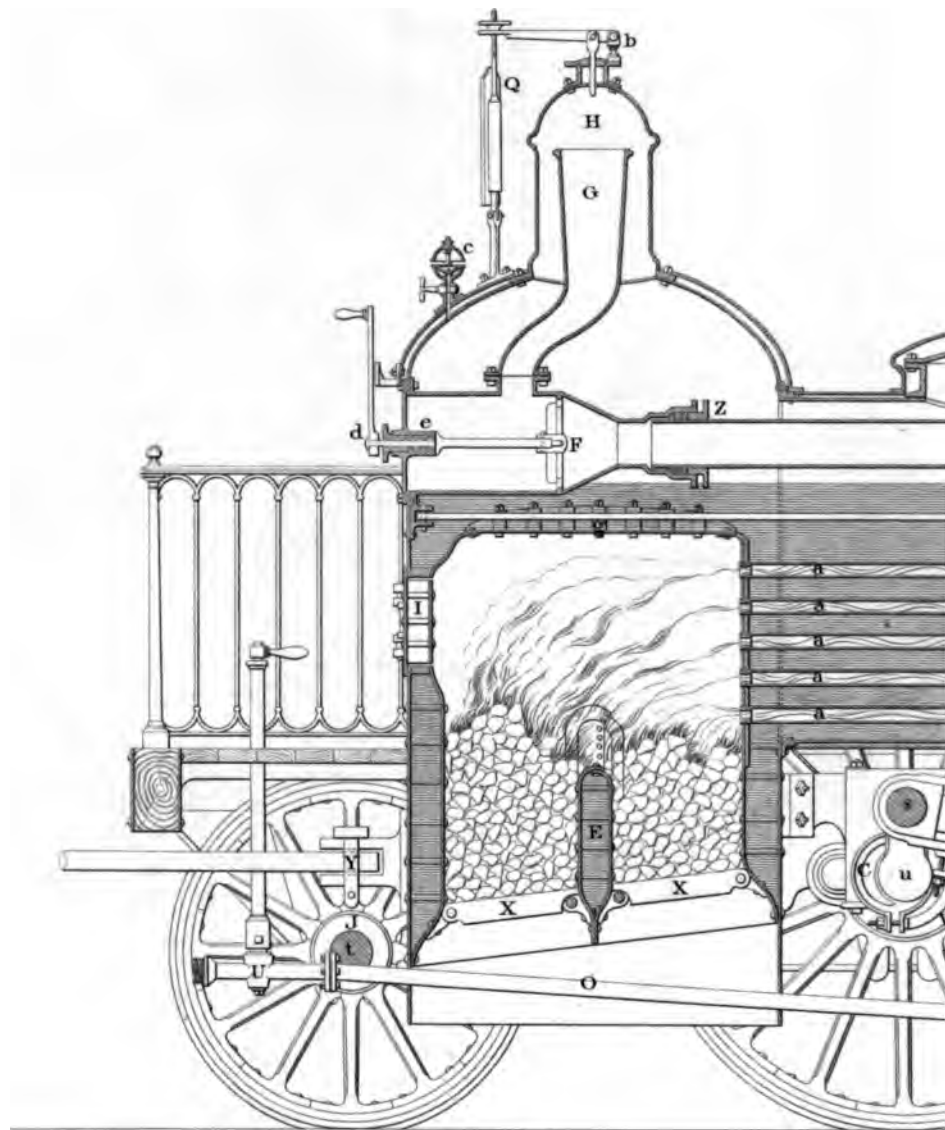
GOODS ENGINE
ON THE
LONDON & BIRMINGHAM RAILWAY.

CLASS E.E. 1



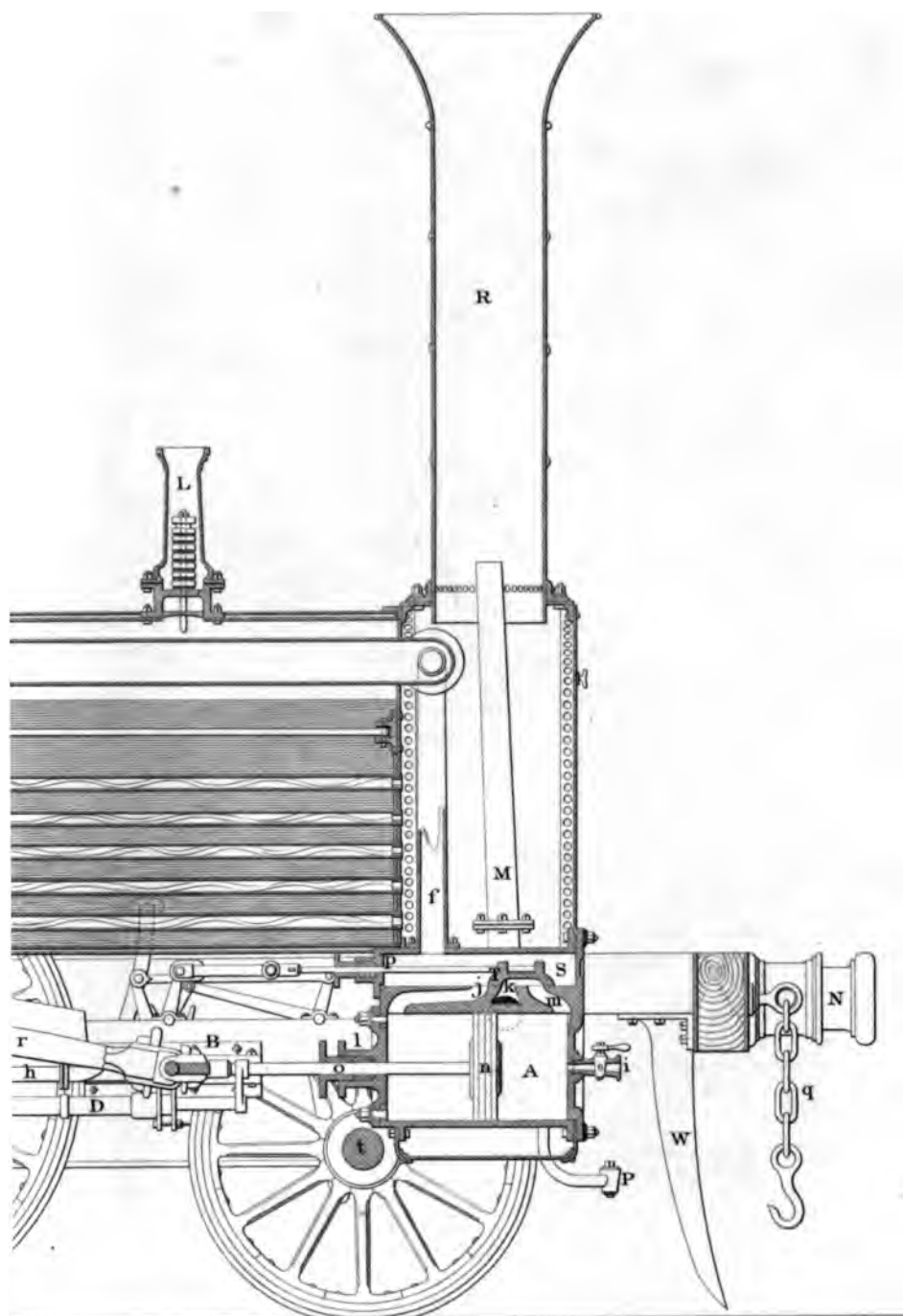
1

LONGITUDINAL SECTION



Inches 12 9 6 3 0 2

LOCOMOTIVE ENGINE.

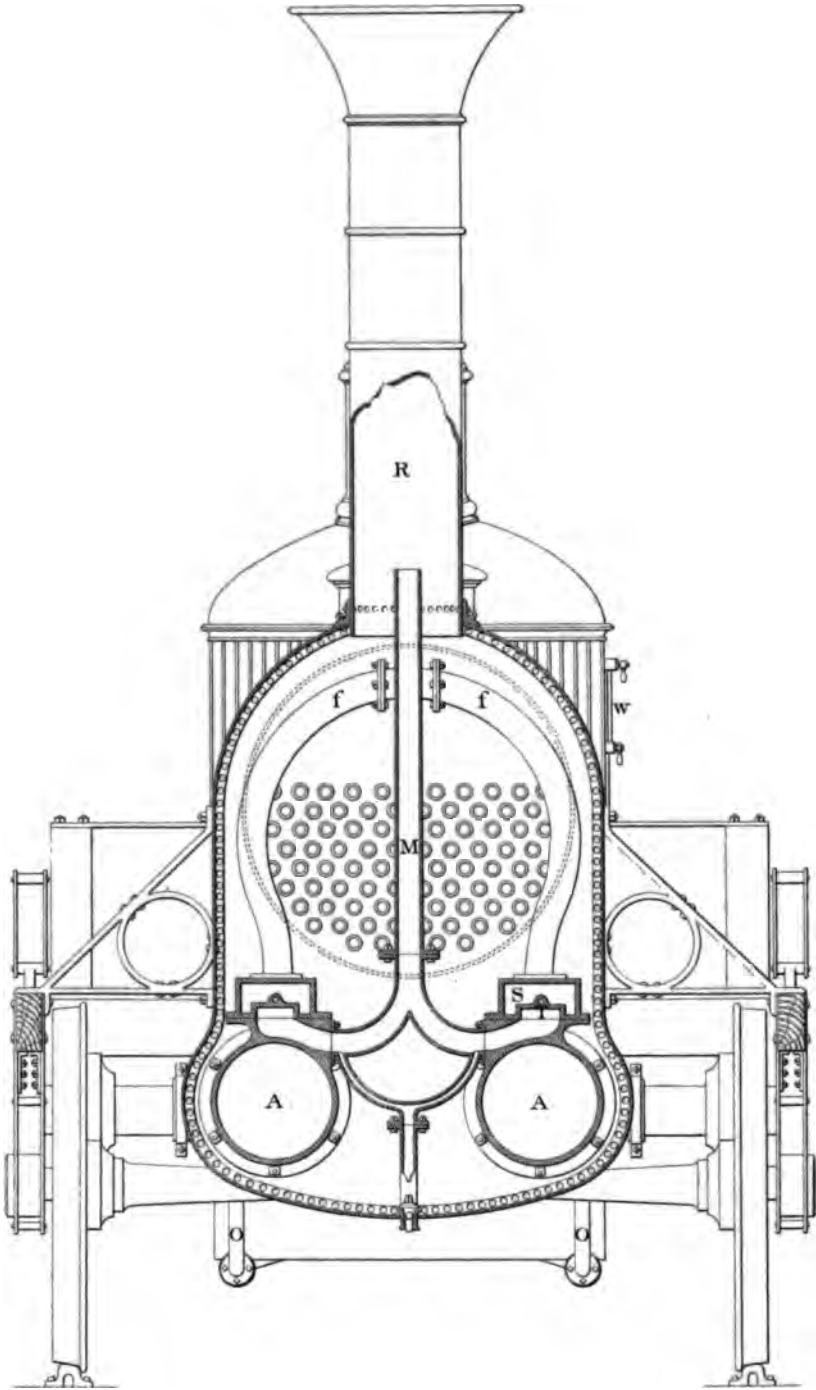


6 8 10 12

Feet .

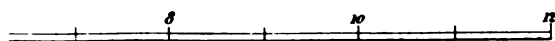
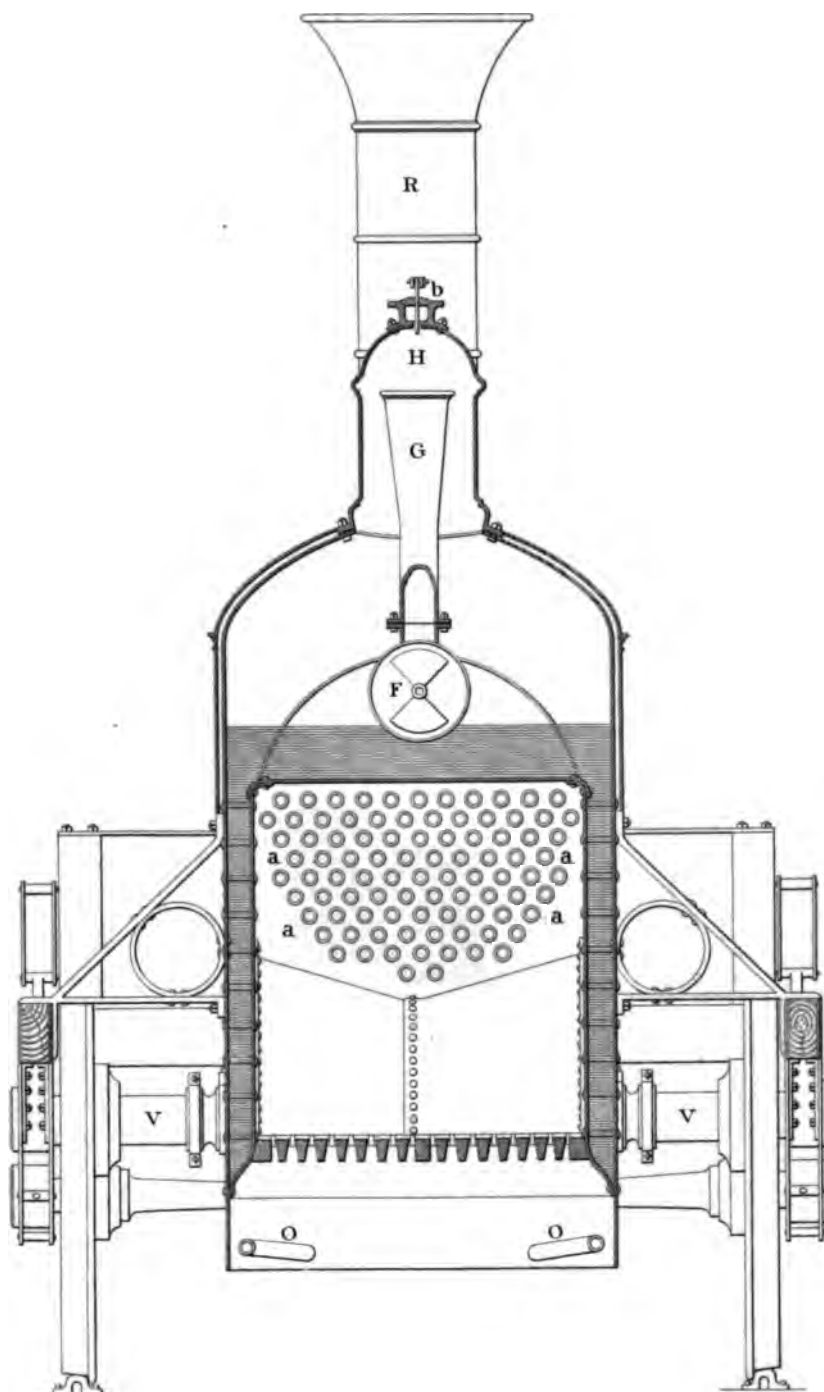


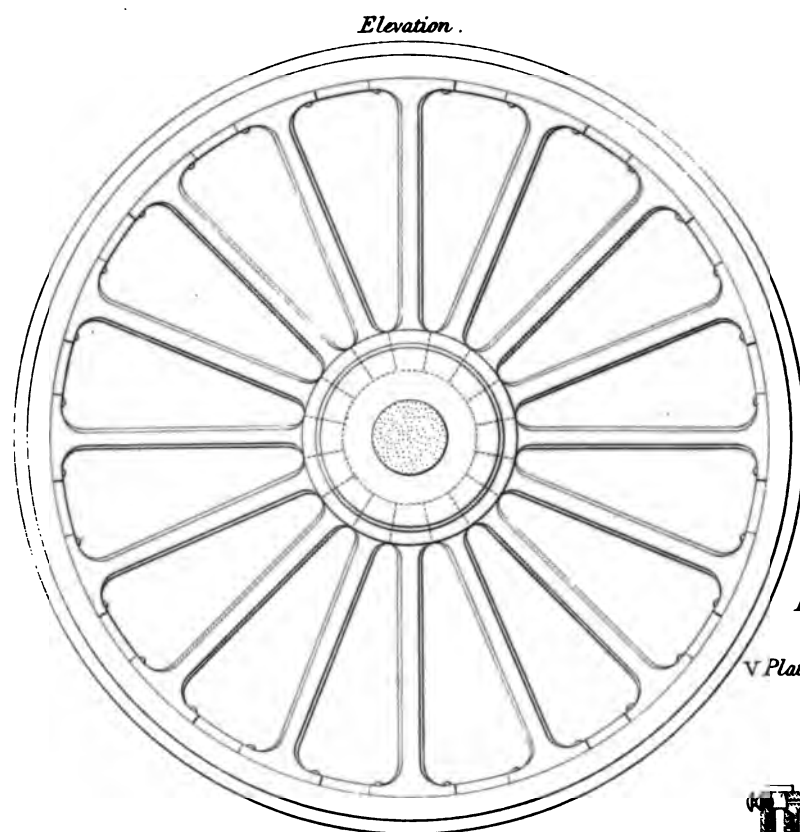
TRANSVERSE SECTIONS



Inches 12 9 6 3 0 2 4

LOCOMOTIVE ENGINE .





Section.

DETAILS OF

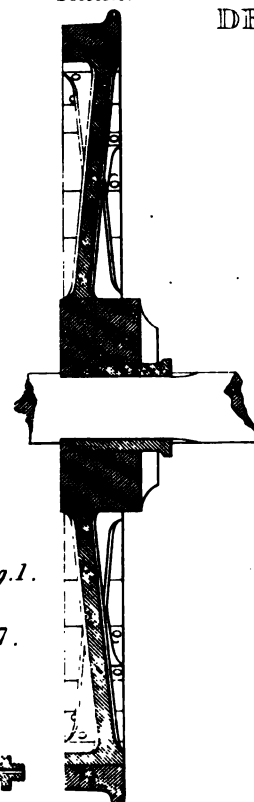


Fig. 1.

Plate. 7.



Fig. 6.

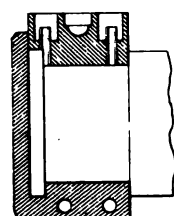


Fig. 3.

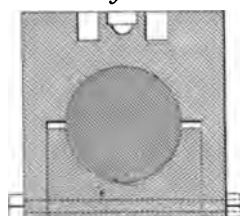


Fig. 4.

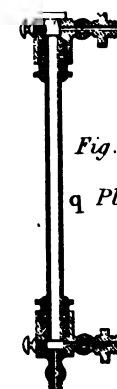
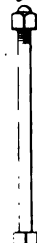


Fig. 5.

q Plate. 8.

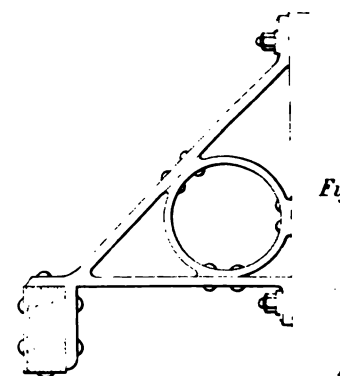


Fig. 7.

Scale of Feet.

Fig 3 & 4.

Longitudinal Section.

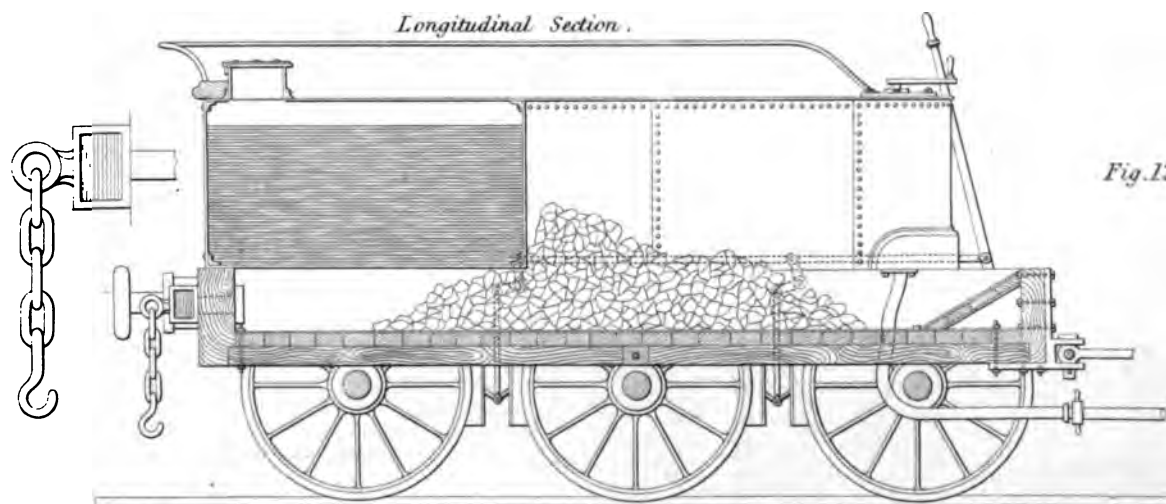
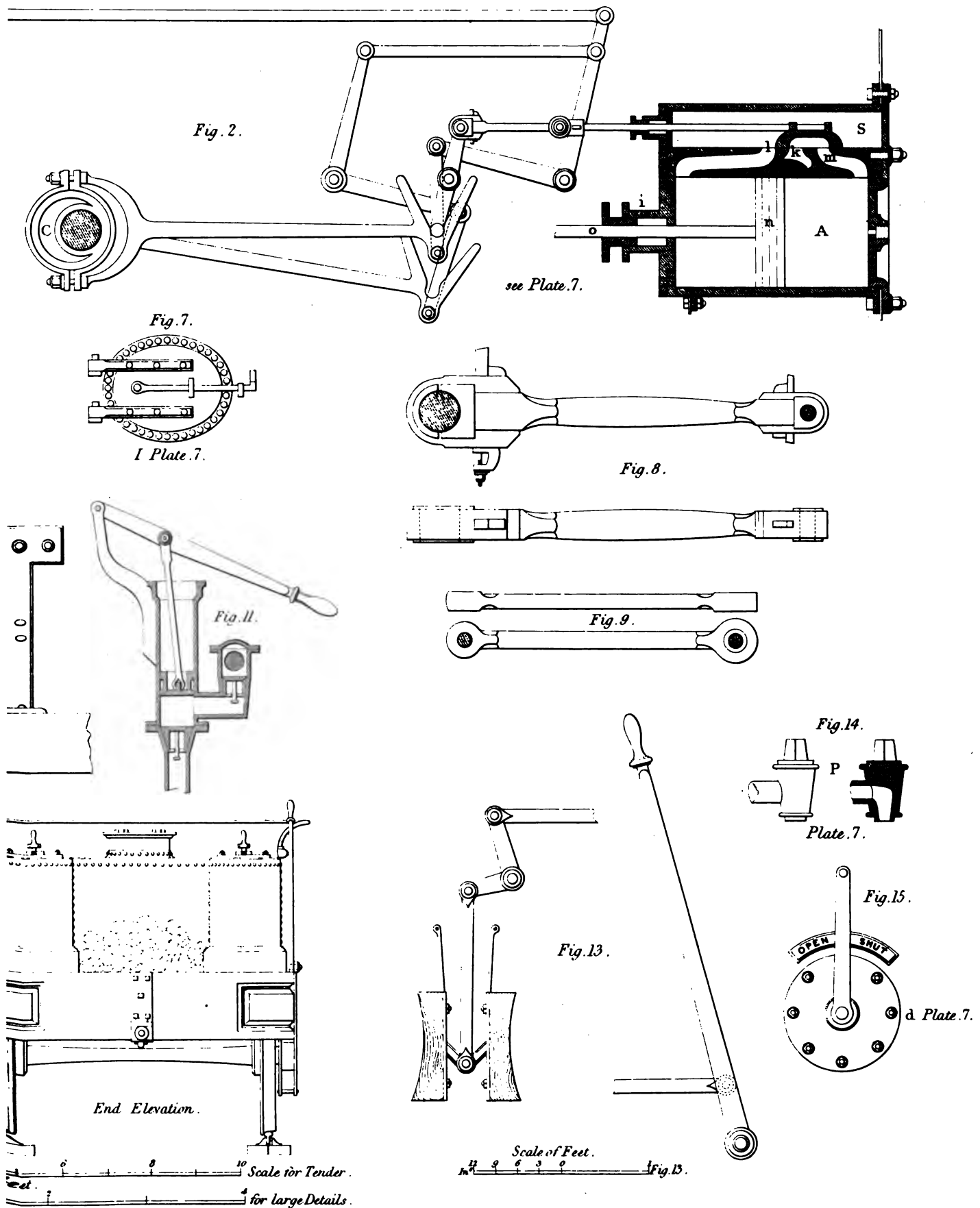


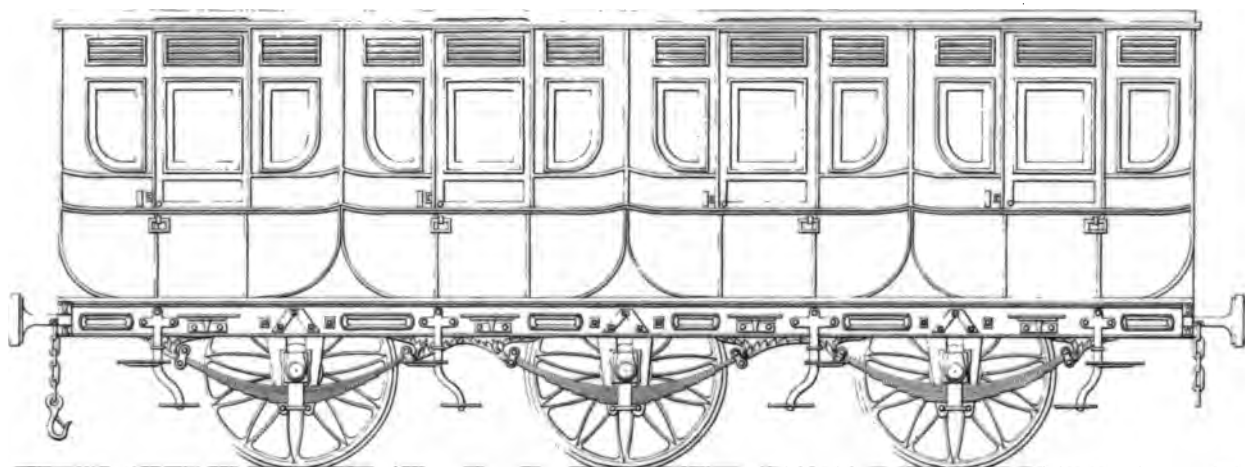
Fig. 12.

12 9 6 3 0 3
12 9 6 3 0

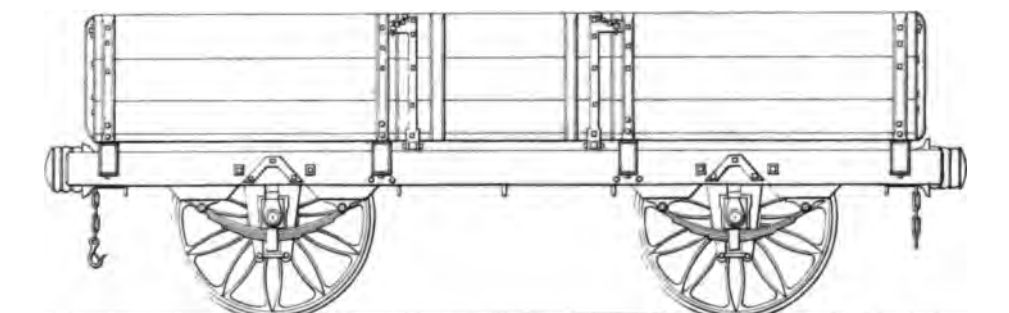
LOCOMOTIVE ENGINE.



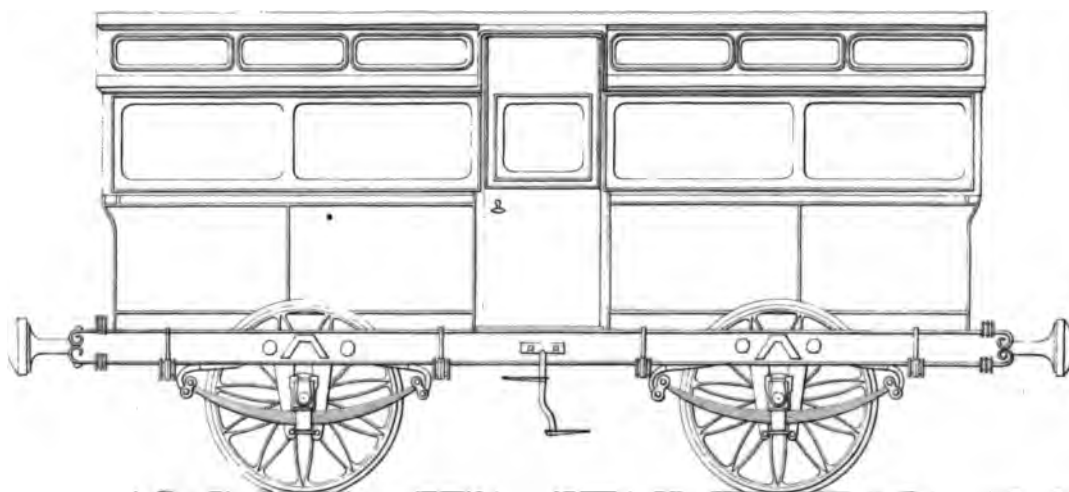




FIRST CLASS CARRIAGE

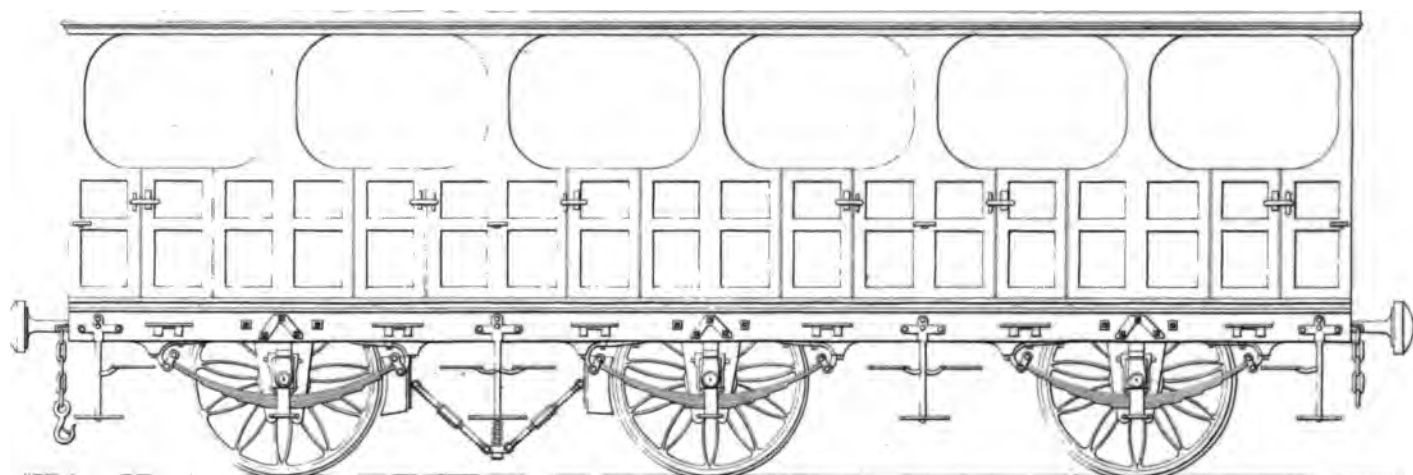


TRUCK



POSTING CARRIAGE

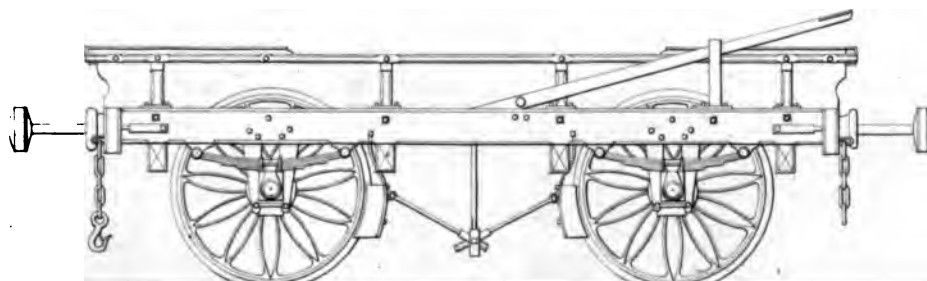
Inches 12 0 1 2 3 4 5 6 7 8 Feet



SECOND CLASS CARRIAGE



HORSE BOX

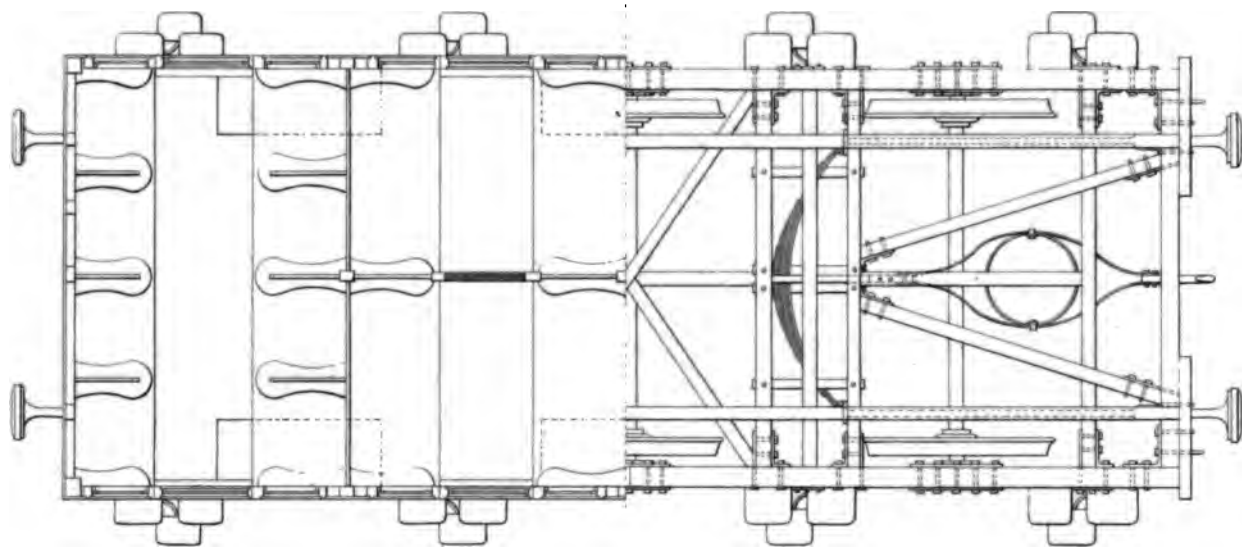


CARRIAGE TRUCK

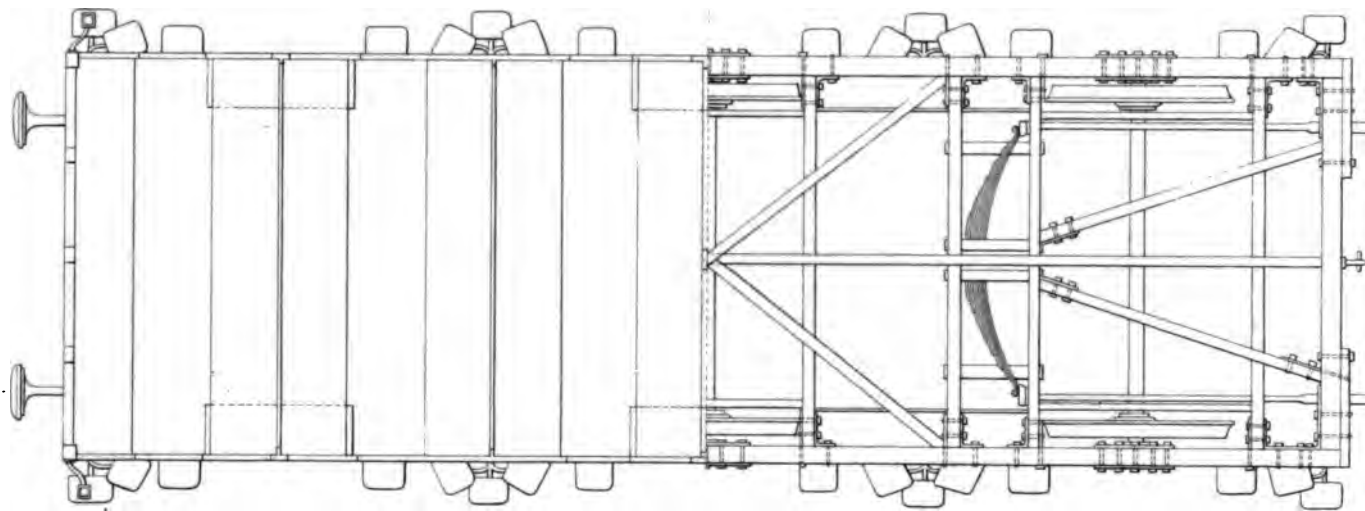
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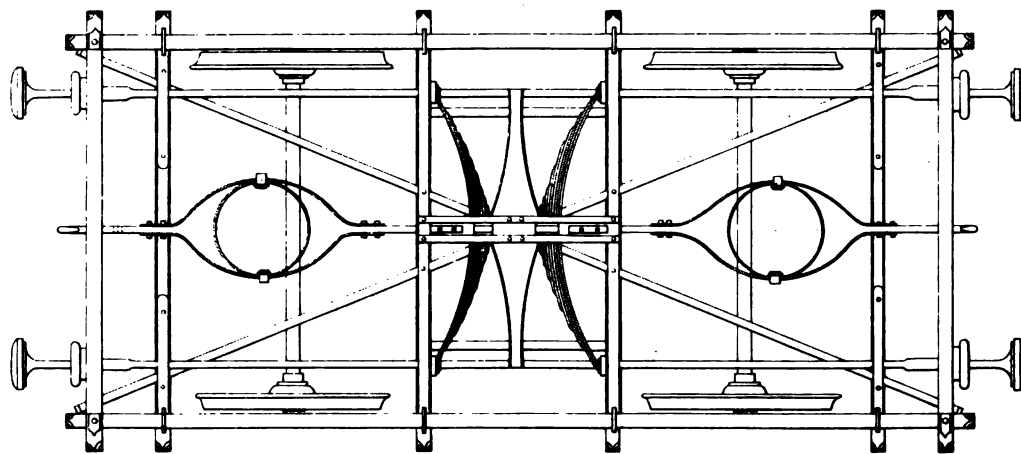




FIRST CLASS CARRIAGE.

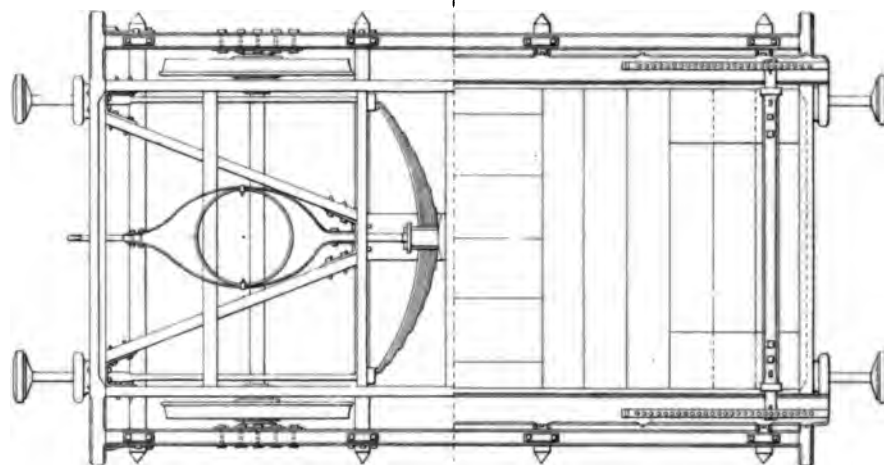


SECOND CLASS CARRIAGE.

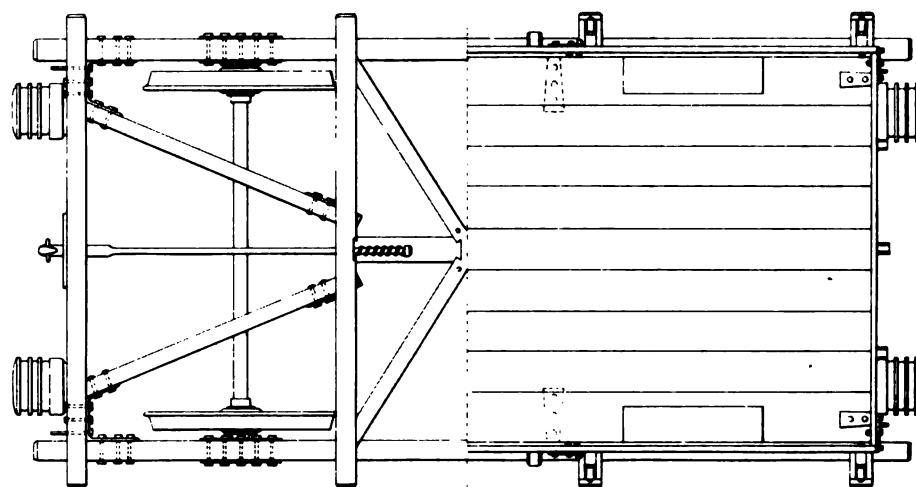


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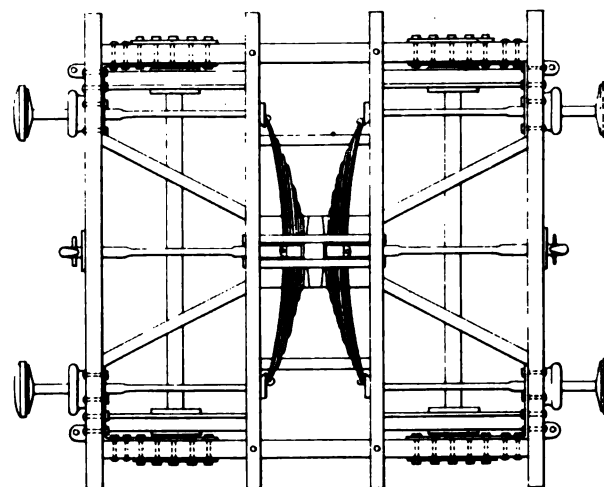
RAILWAY CARRIAGES.
L. J. S.



PLAN OF CARRIAGE TRUCK.



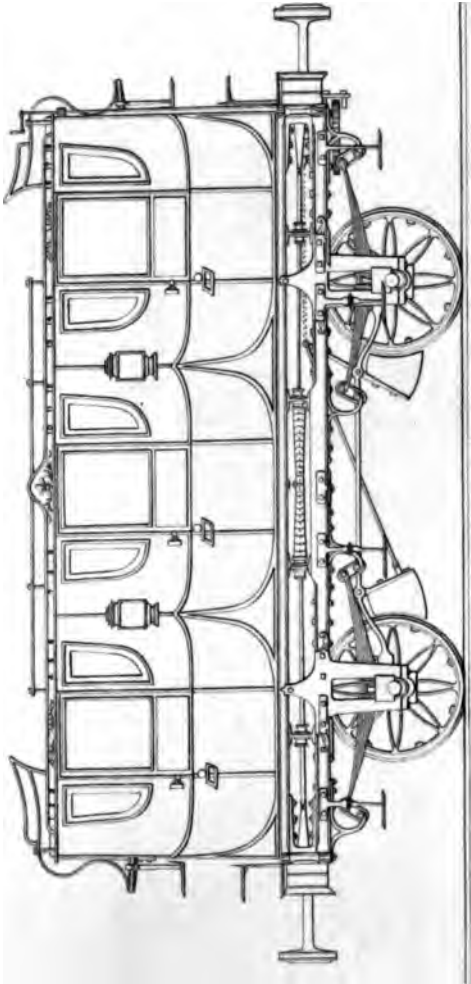
PLAN OF WAGON.



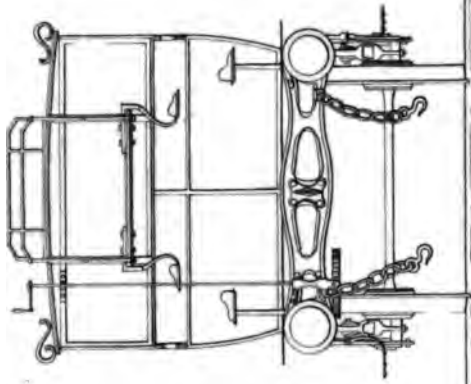
PLAN OF HORSE BOX, FOR FOUR HORSES.

3 4 5 6 7 8 9 10 Feet

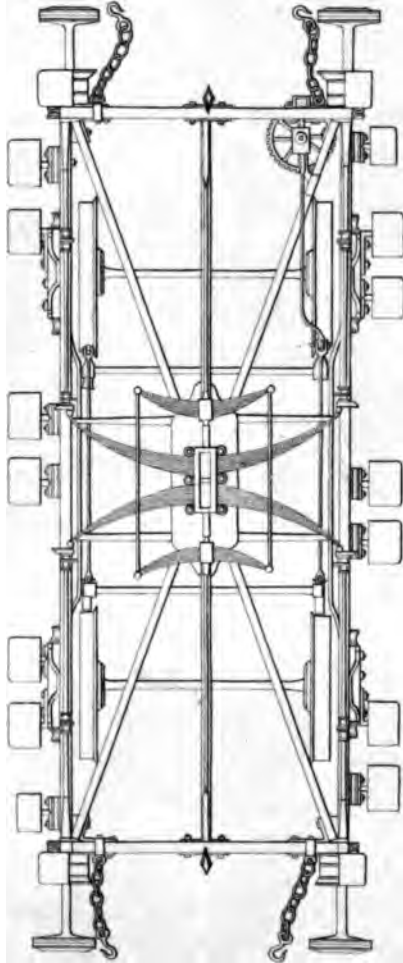




ELEVATION OF FIRST CLASS CARRIAGE.

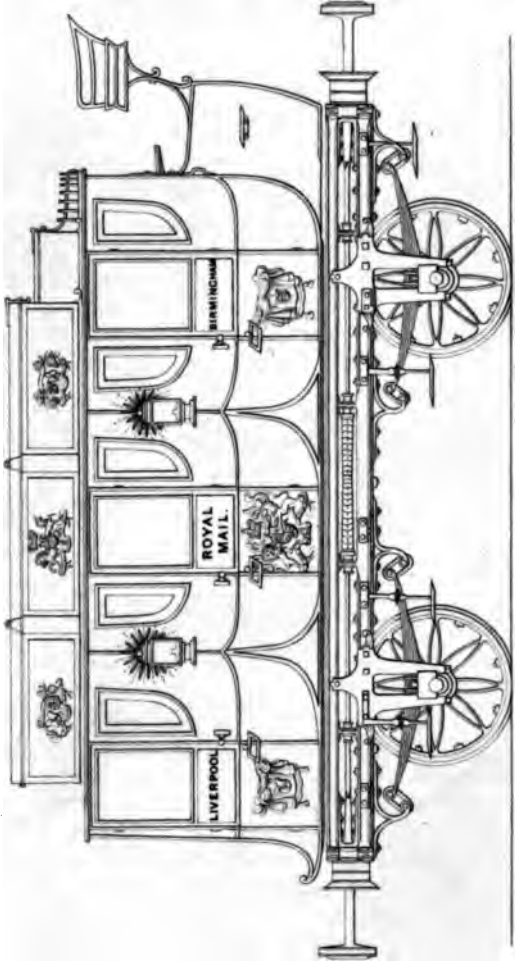


END ELEVATION OF FIRST CLASS CARRIAGE.

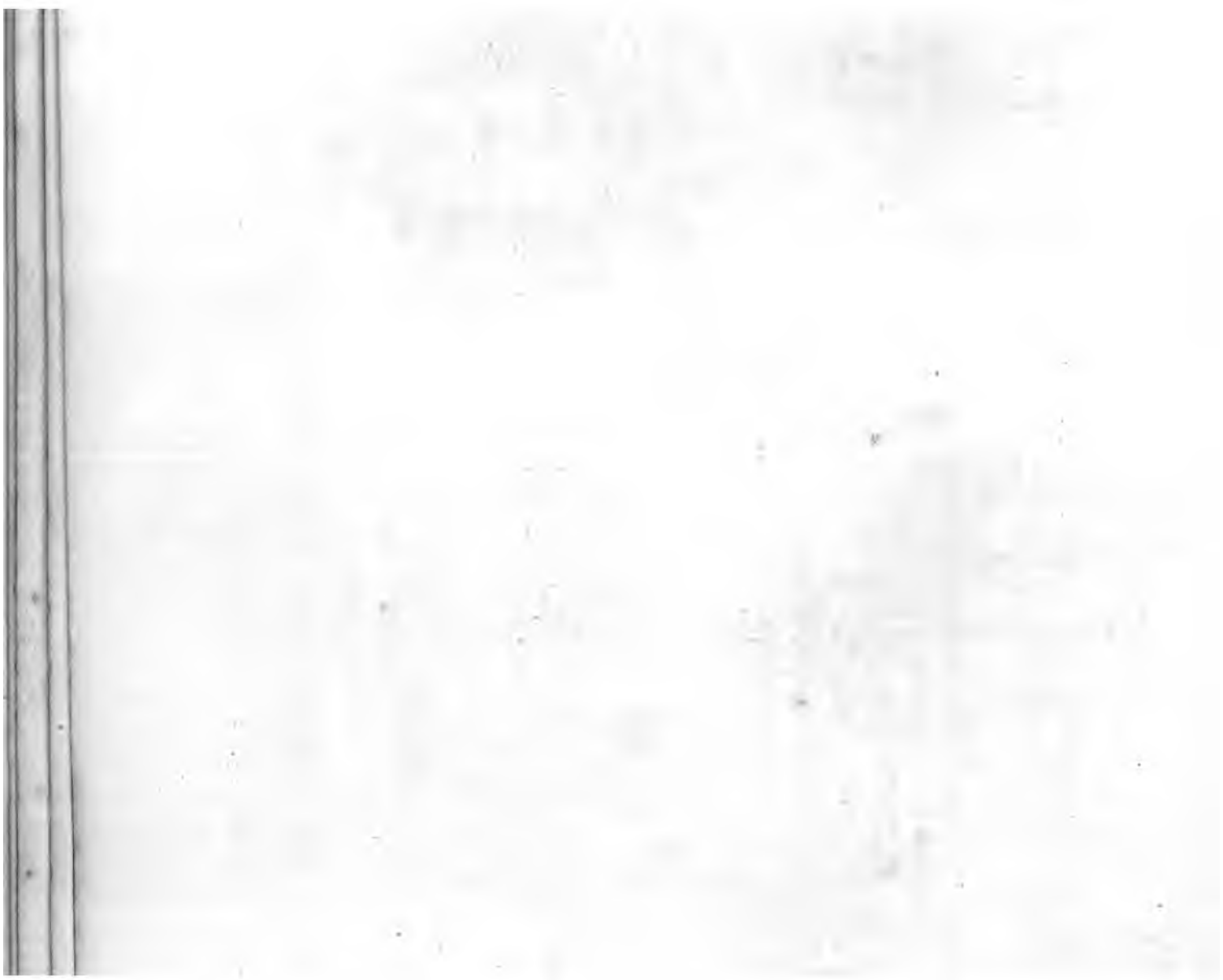


FIRST CLASS CARRIAGE.

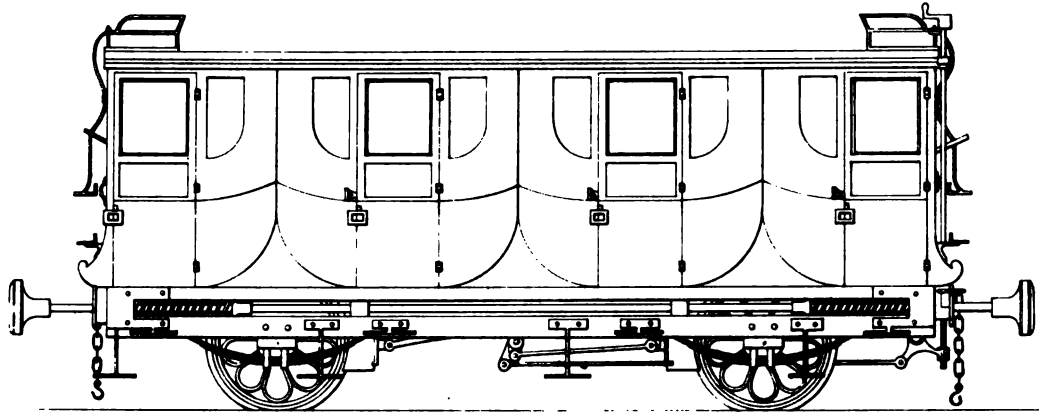
Inches 2 1 2 3 4 5 6 7 8 9 10 Feet



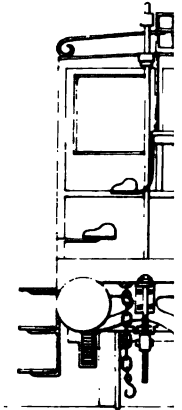
ELEVATION OF ROYAL MAIL.



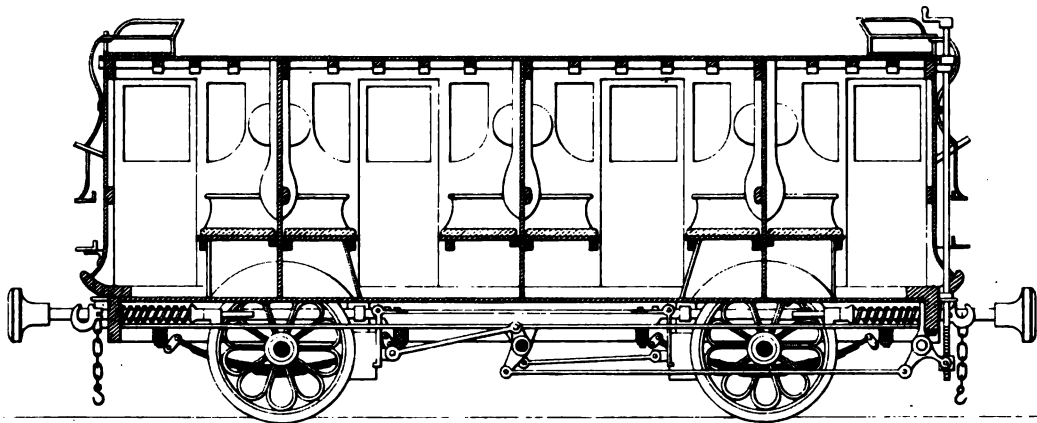
FIRST CLASS



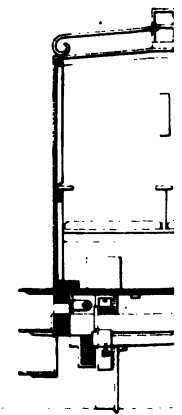
ELEVATION



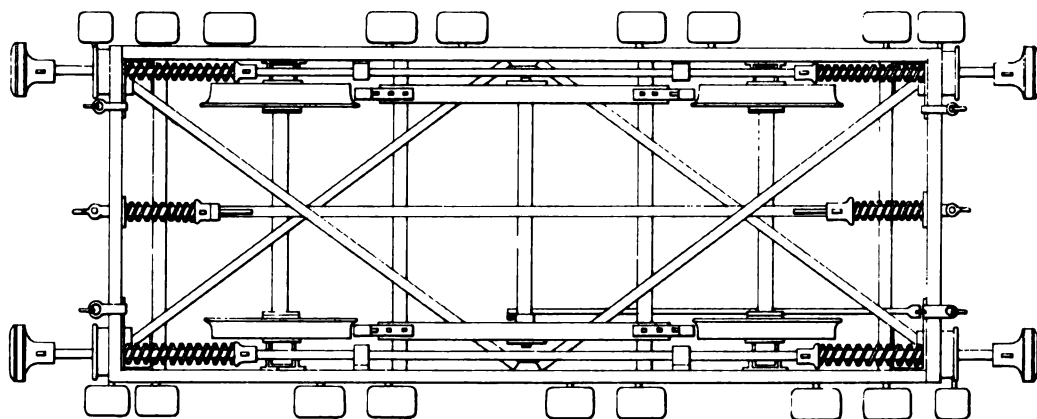
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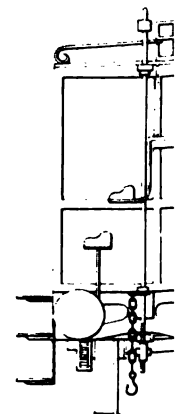
SECTION



TRANS

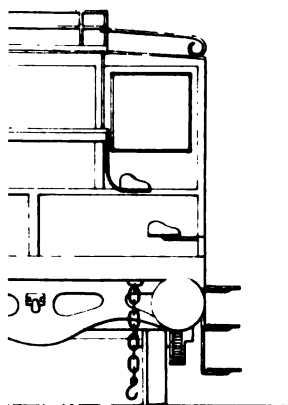


PLAN

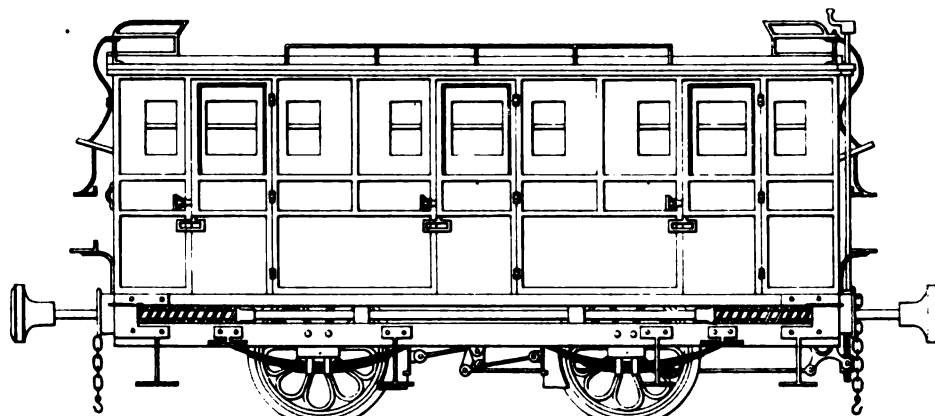


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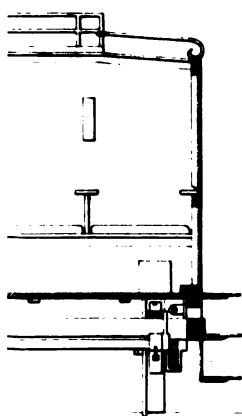
SECOND CLASS



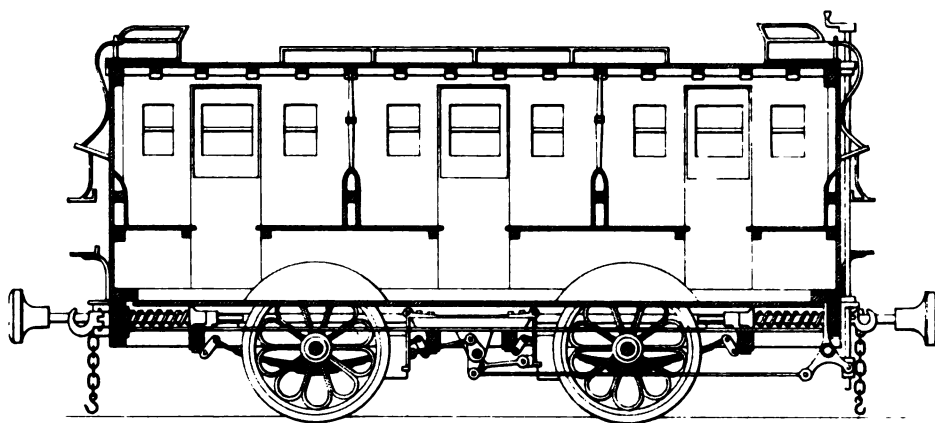
FIRST CLASS
ELEVATION



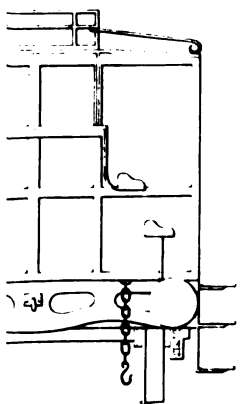
ELEVATION



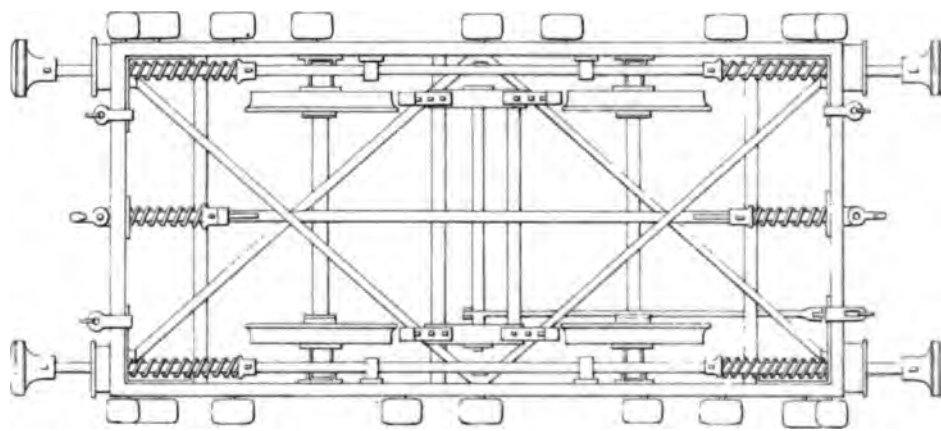
FIRST CLASS
SECTION



SECTION



THIRD CLASS
ELEVATION

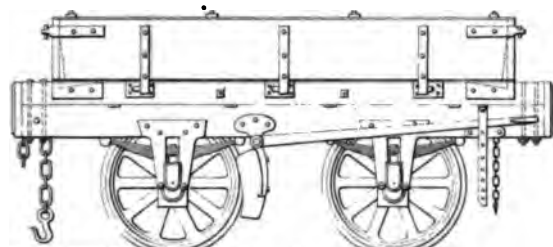


PLAN



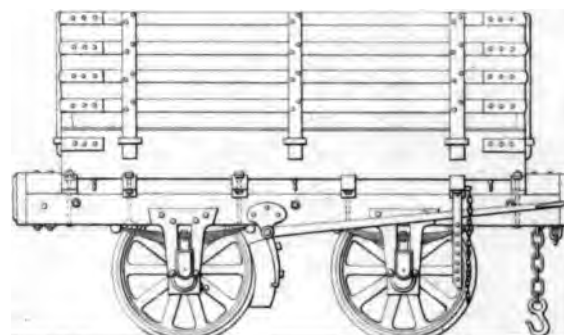
BIRMINGHAM AND GLOSTER RAILWAY WAGONS.

BALLAST WAGON

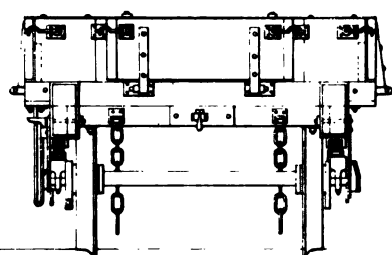


ELEVATION

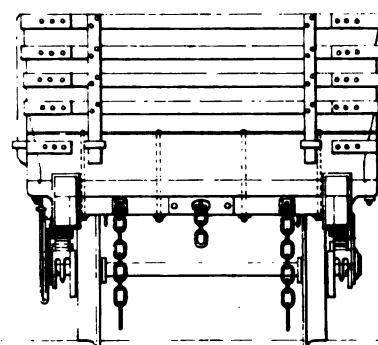
GOODS WAGON



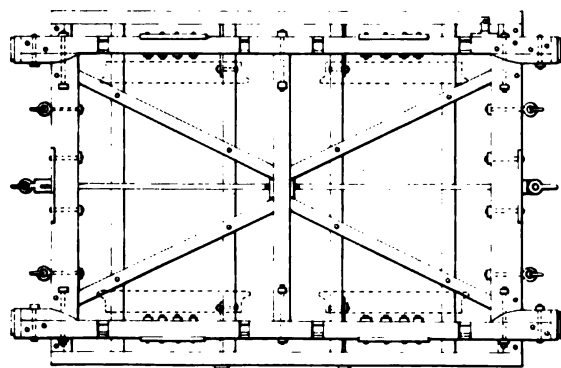
ELEVATION



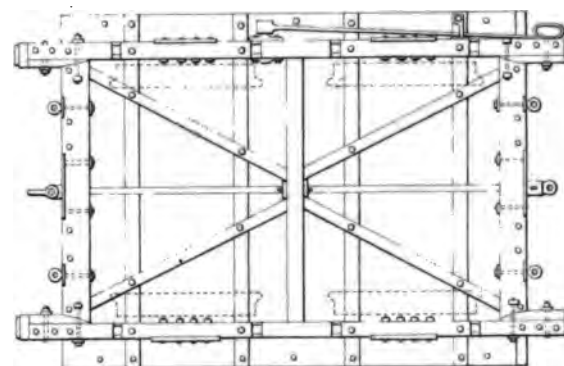
END ELEVATION



END ELEVATION



PLAN



PLAN

W. Jackson Del.

Inches 0 3 6 9 12 1 2 3 4 5 6 7 8 9 10 Feet

F. Mansell Sculp.



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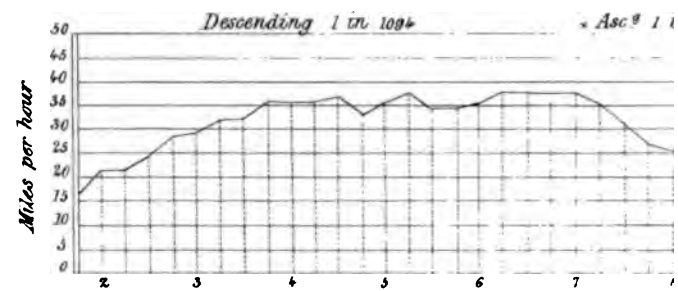
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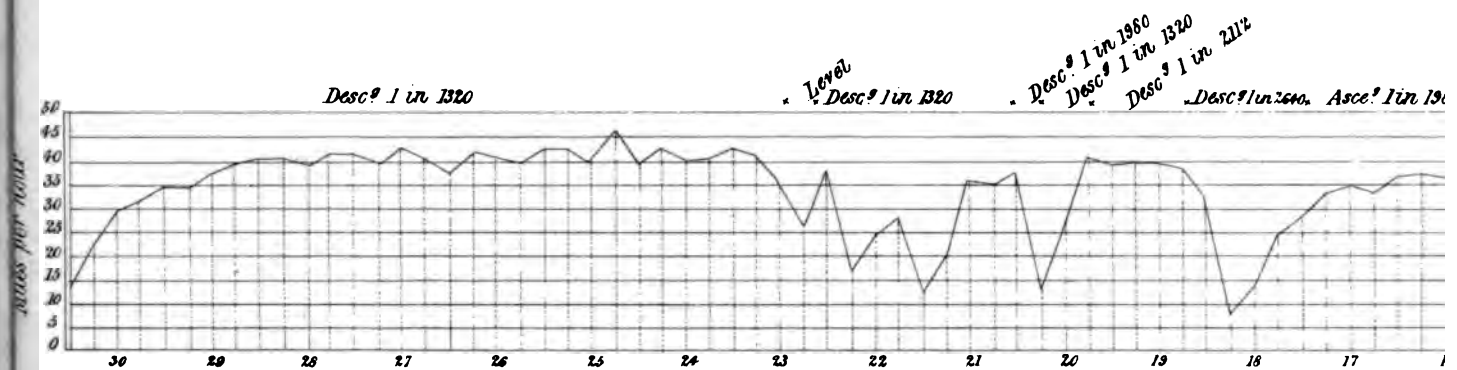
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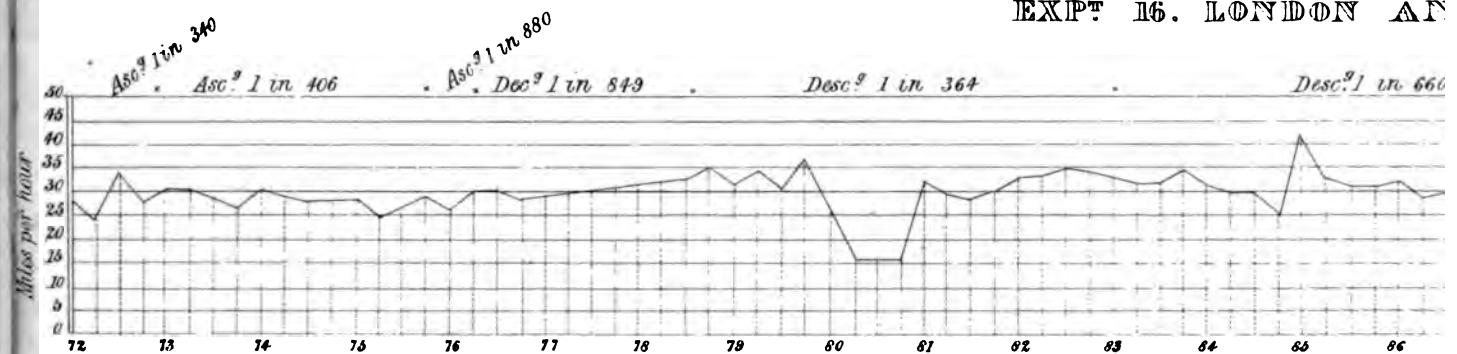
EXPT 6. LIVERPOOL



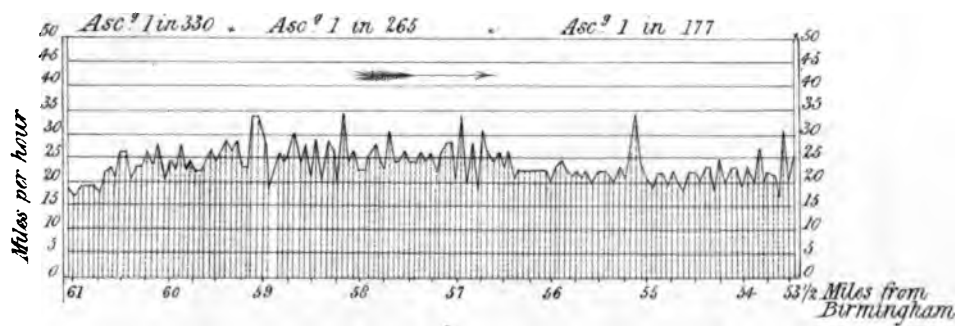
EXPT 25. GREAT



EXPT 16. LONDON AN

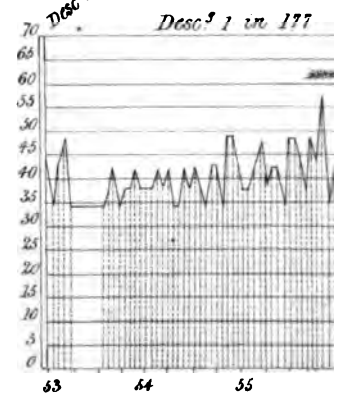


EXPT 6. GRAND JUNCTION RAILWAY.



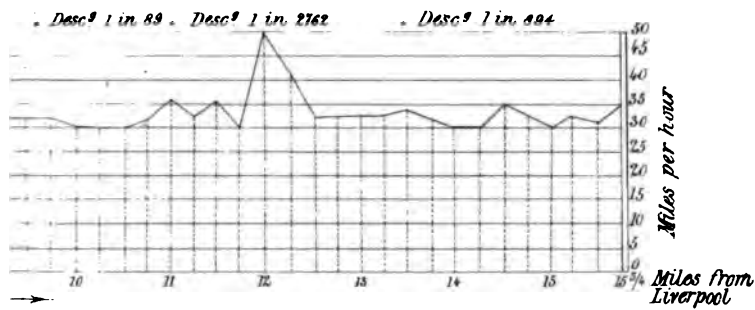
H P Hughes, del

EXPT 16. GIRA

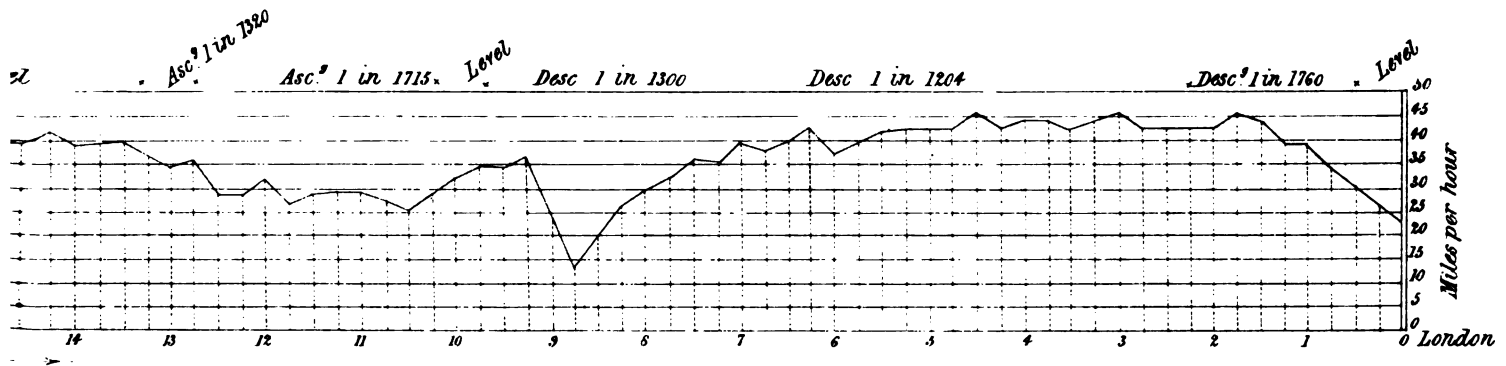


MANCHESTER RAILWAY.

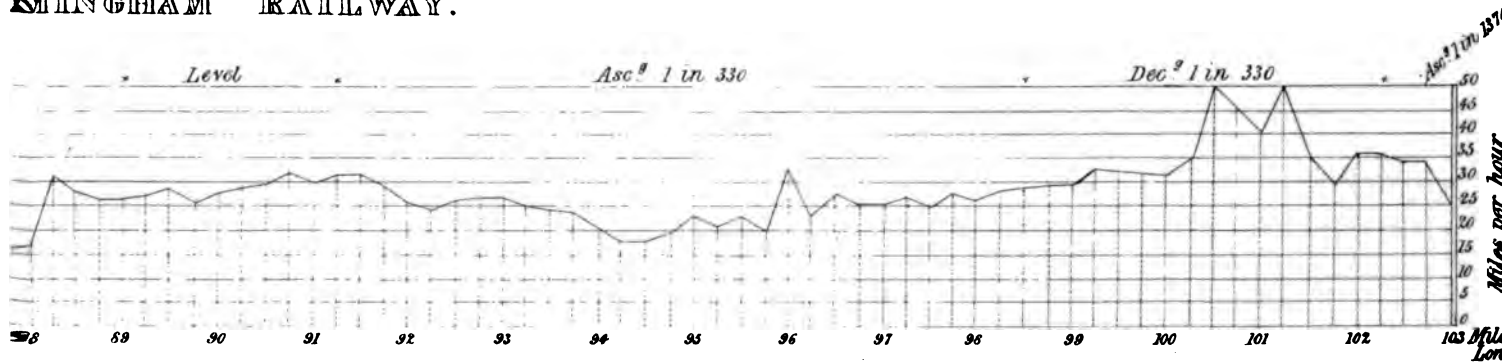
Plate 15.



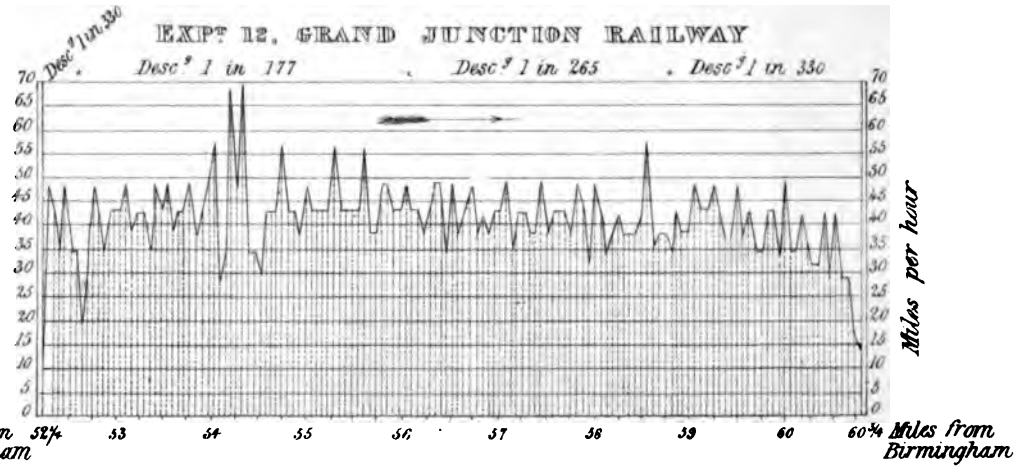
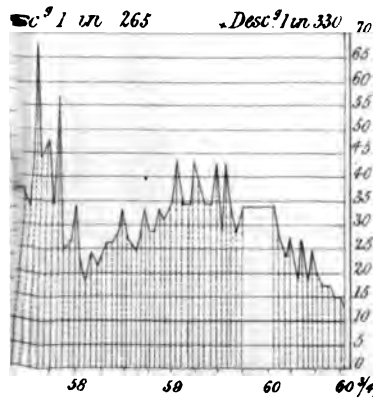
ERN RAILWAY.



BIRMINGHAM RAILWAY.

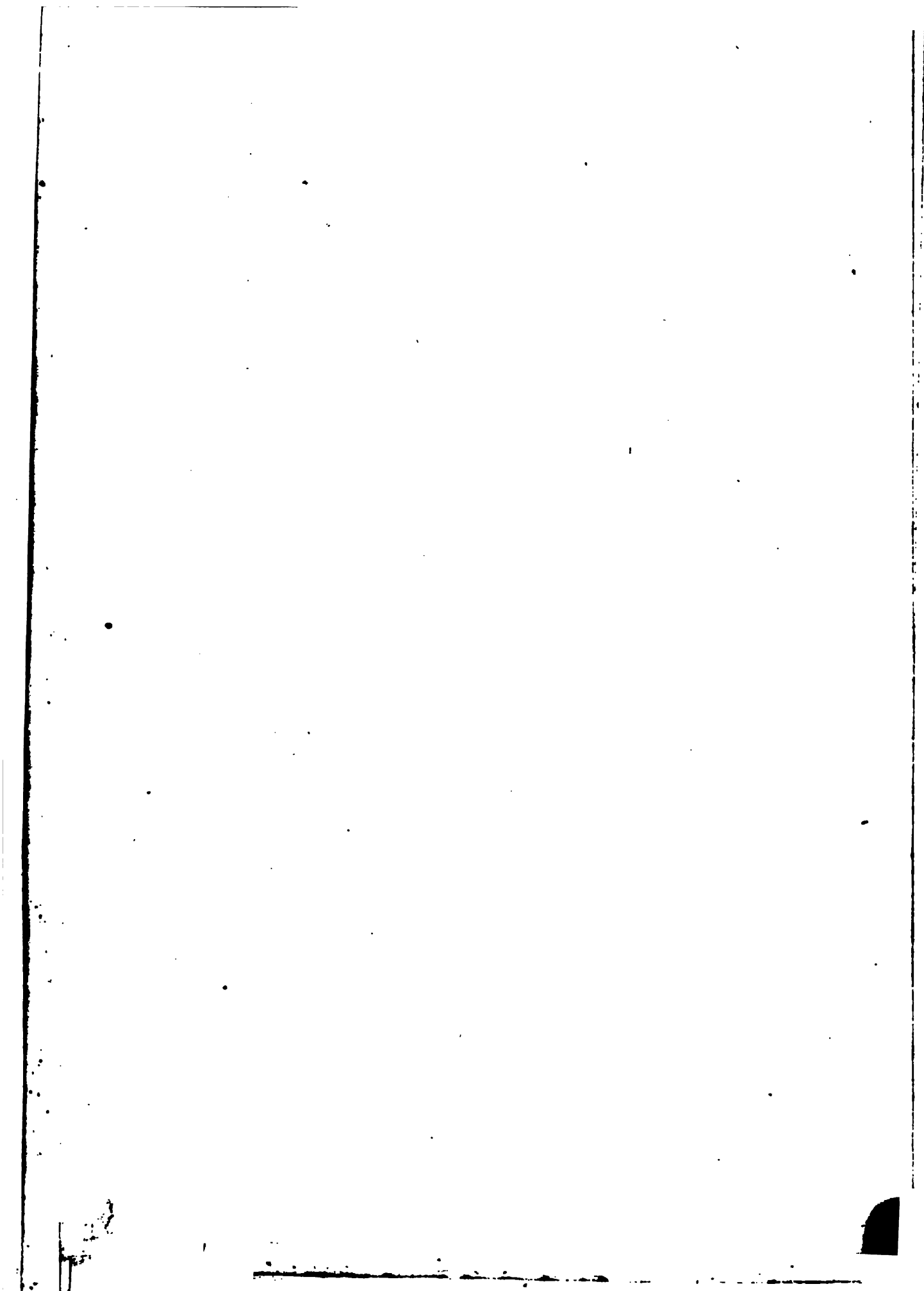


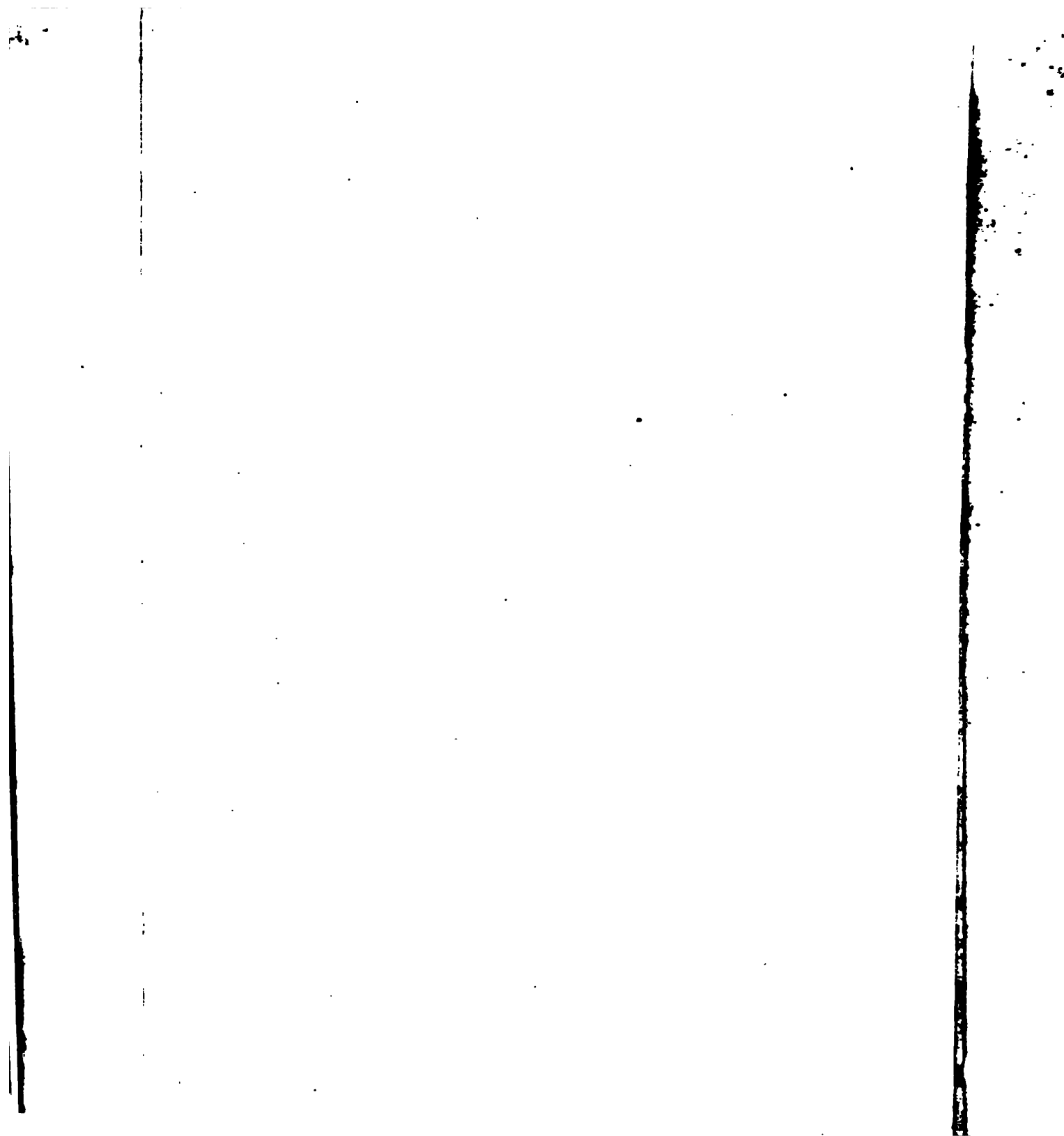
TION RAILWAY.

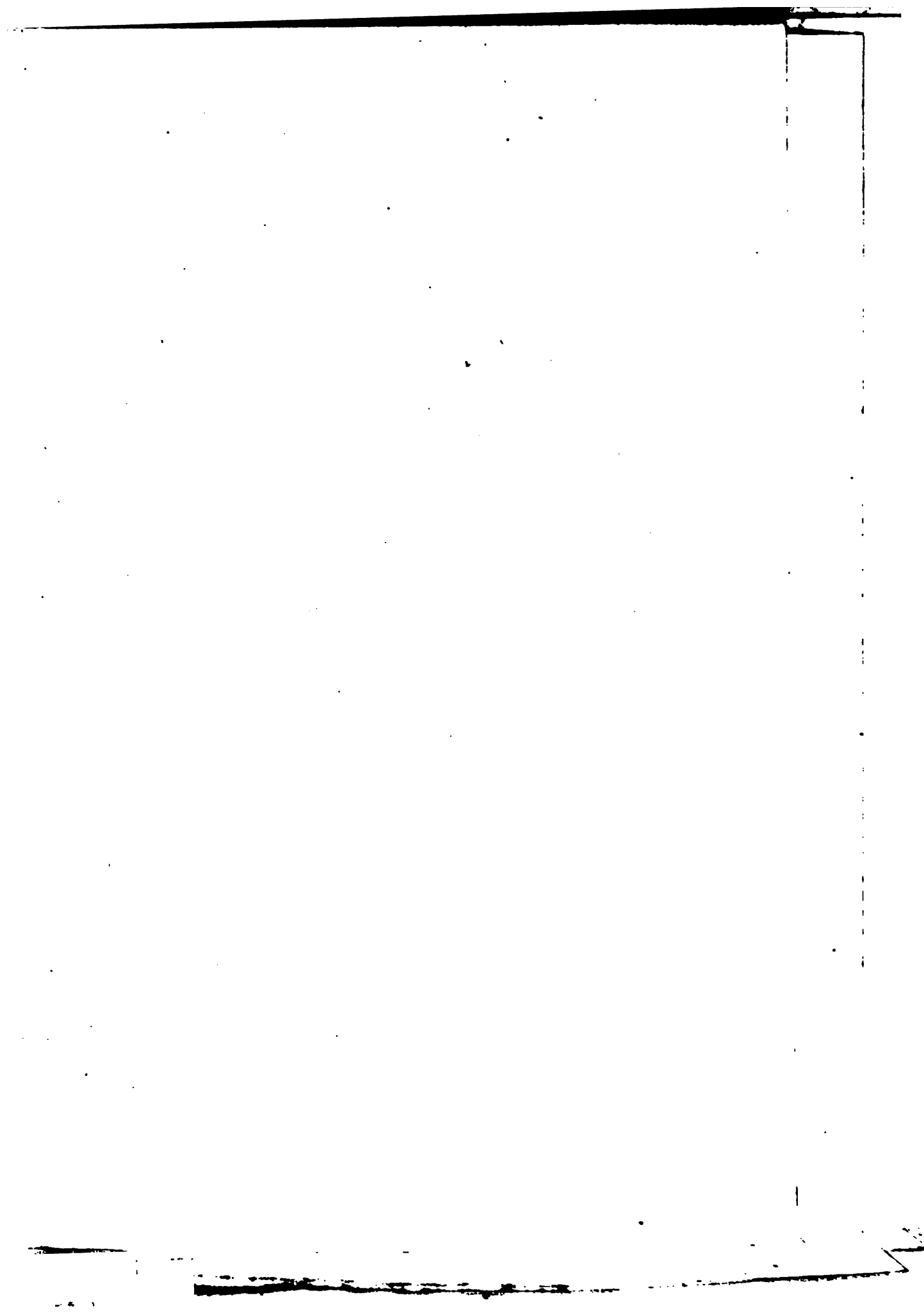


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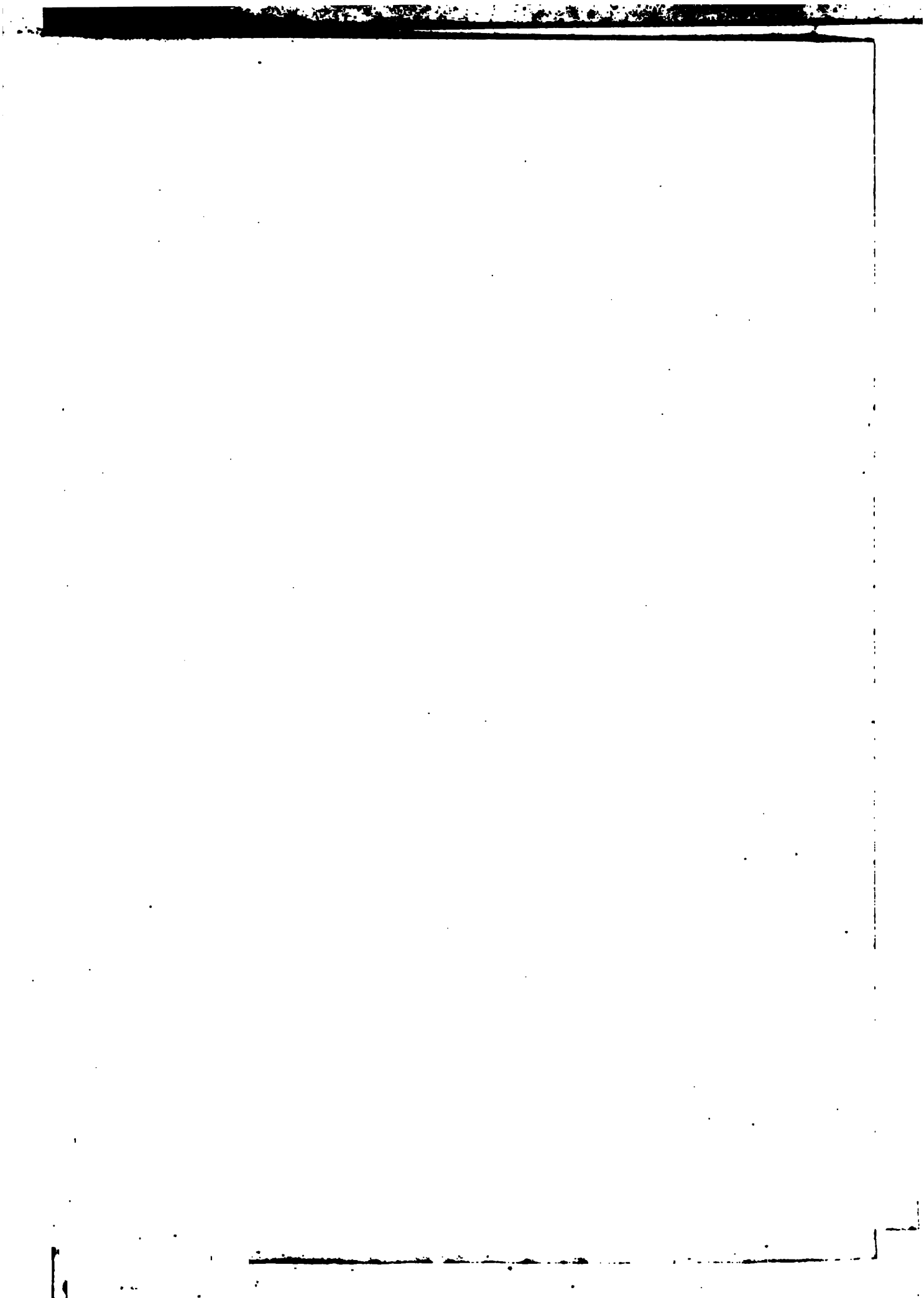








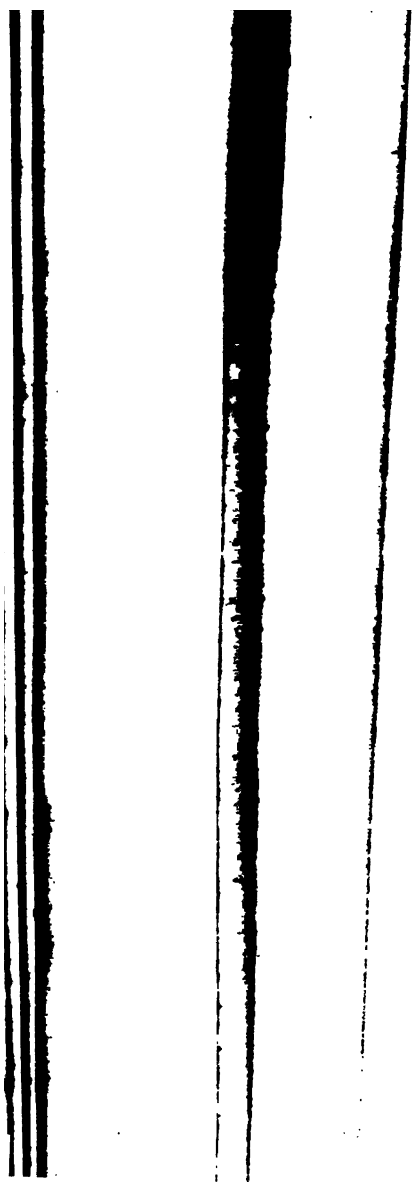
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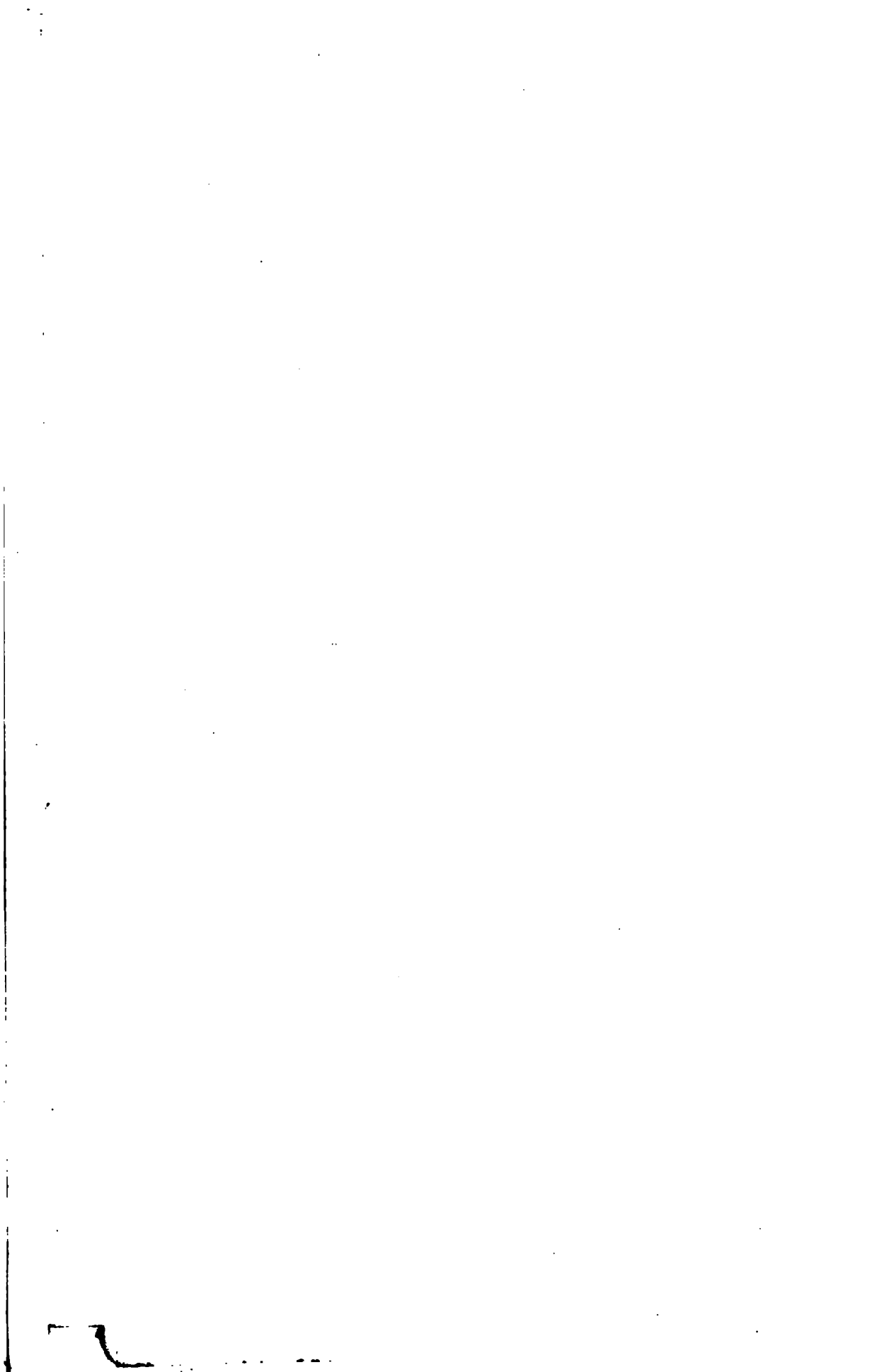




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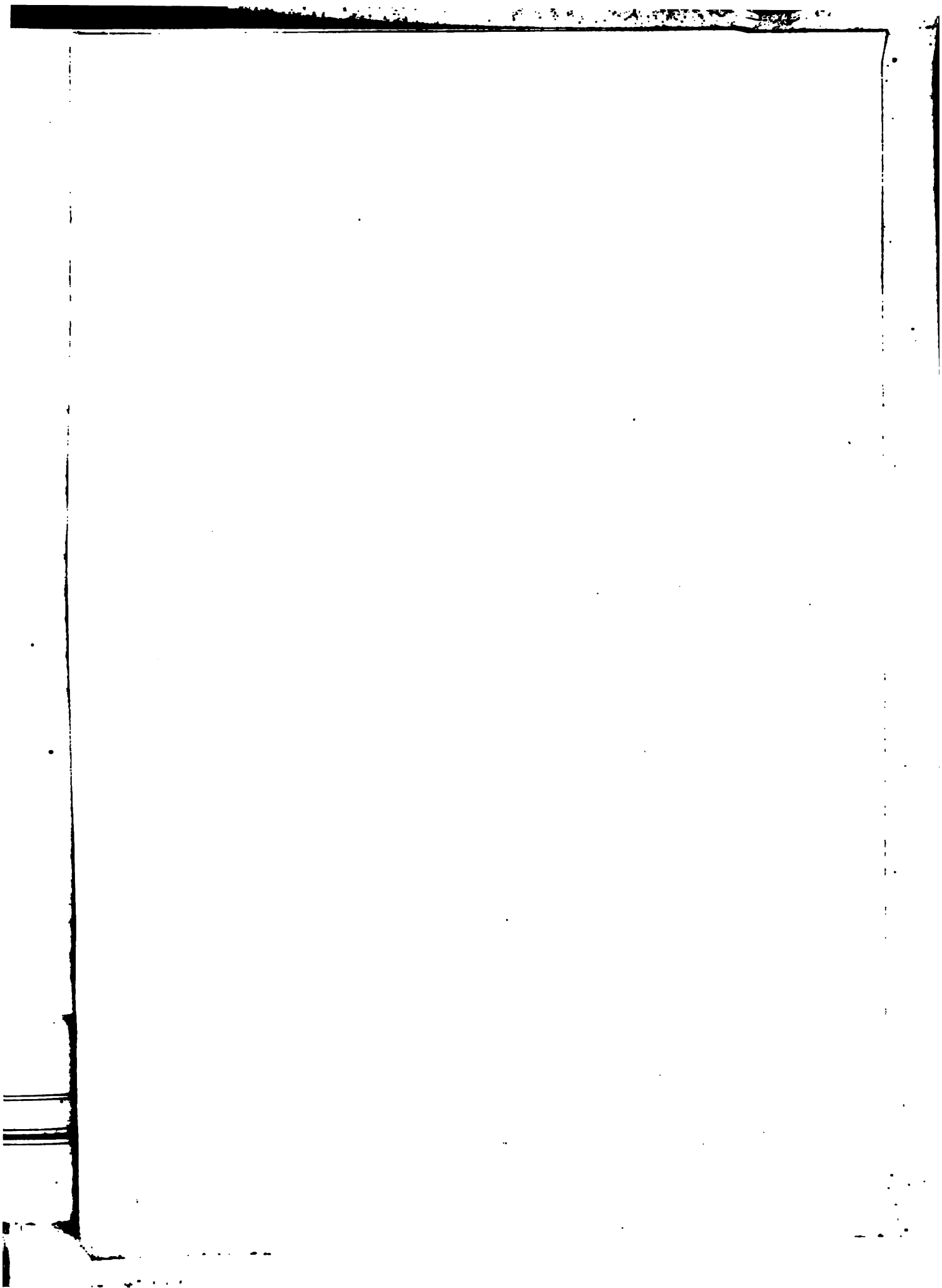




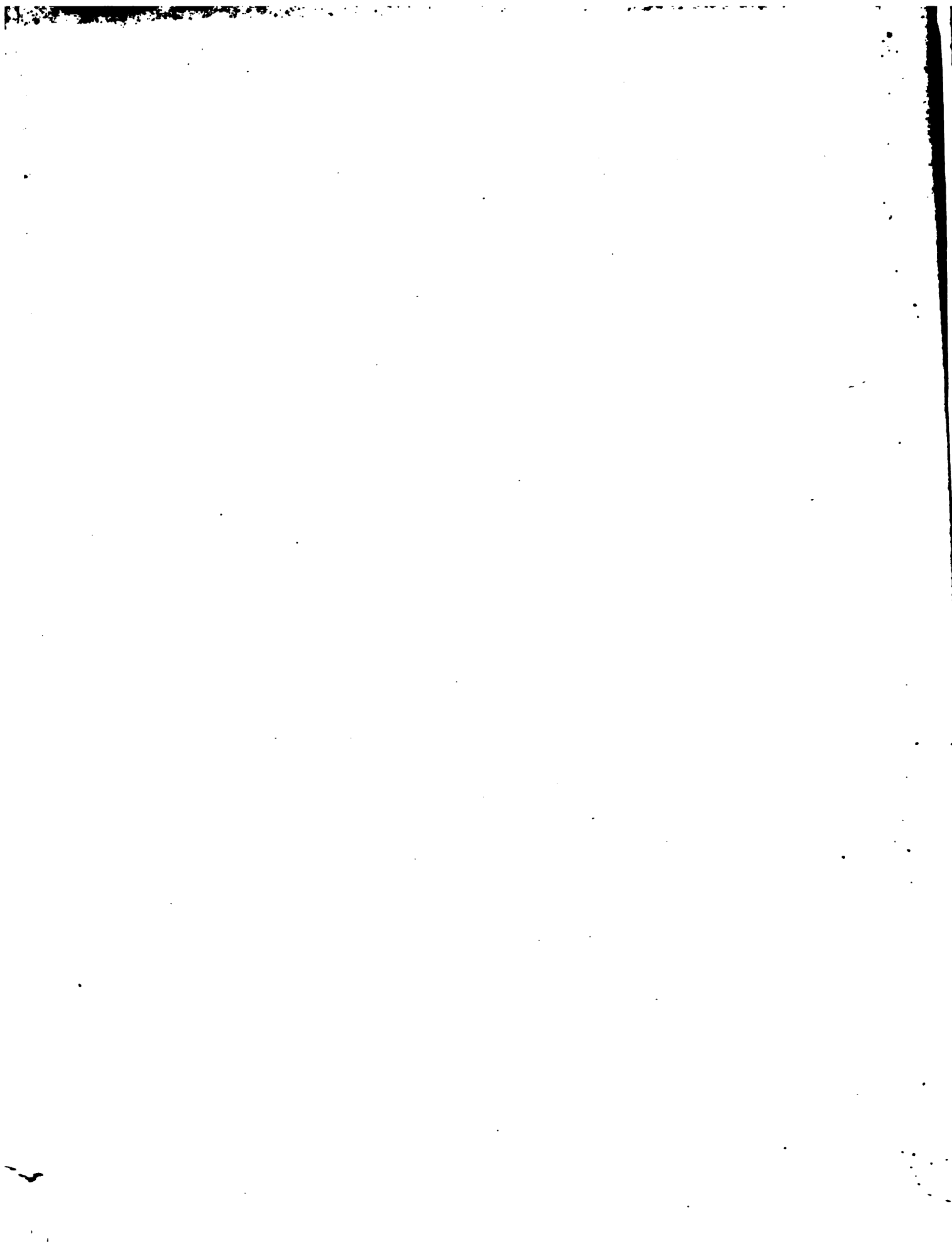


Francis Whiskaw

F. Rumble, del^t



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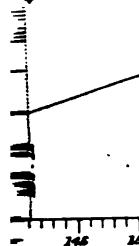
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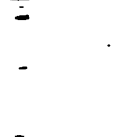
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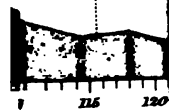
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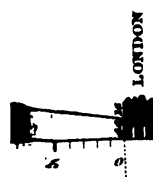


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